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ADDRESSES AND PAPERS

BY

THE MEMBERS OF THE
INSTRUCTING STAFF OF
THE NEW YORK STATE
VETERINARY COLLEGE

FOR THE YEARS 1896–1898

"THERE IS HEREBY ESTABLISHED
A STATE VETERINARY COLLEGE
AT CORNELL UNIVERSITY"
Laws of New York, 1894, p. 307

ITHACA, NEW YORK
1898

1961

PREFATORY NOTE

This collection of fifty-eight papers and addresses, representing nearly five hundred pages of matter, has been selected from the published work of the various members of the instructing staff of the New York State Veterinary College during the two years of its existence. The work is now presented to the members of the Veterinary and Medical professions, to scientific men, stock raisers, and indeed to all who are interested in the prosperity of our great commonwealth, and the advancement of science.

The papers show something of the variety of the intellectual work undertaken by the teachers both within and outside the direct line of their college duties. This will serve to explain the extremely varied and heterogeneous character of the contents, ranging as they do through the following general subjects: The value of certain forms of scientific study as a means of mental training; physiology and other scientific courses in common schools and academies; results of scientific investigations in natural history; laboratory methods which systematize, simplify and render more effective scientific research; the results of laboratory work in their bearing on the economic management of our live stock industry and the sanitary protection of the human race; advances and improvements in medical and surgical methods; the feasibility and importance of the extinction of the microbes of certain plagues now prevalent on this continent, and the best means of maintaining and advancing the standard of veterinary education and practice in the State and Nation. Our last announcement is placed at the end of the volume and shows, in outline, the preliminary and professional education which seems to us absolutely essential.

While some of the monographs are complete in themselves, others may be said to be reports of progress in a given line of investigation, for the full elucidation of which a much longer time and a greater outlay are necessary. This pertains especially to such subjects as the contagious diseases of swine, which cost the State of New York hundreds of thousands of dollars per annum; and the contagious abortion of cows which entails even greater loss. These and other lines of inquiry of great economic value will be kept constantly in view and followed up as our means and opportunity permit. We hope in future years to report even more valuable results as we reach final and demonstrable conclusions.

In addition to the papers herein printed, translations and much other work have appeared; as a part of this work may be mentioned the following books:

Text Book of Veterinary Medicine, Vol. I. JAMES LAW.

Practical Exercises in Comparative Physiology and Urine Analysis. PIERRE A. FISH.

Laboratory Direction for Beginners in Bacteriology. VERANUS A. MOORE.

The Microscope and Microscopical Methods, 6th Edition. SIMON H. GAGE.

JAMES LAW, *Director.*

DECEMBER 5, 1898.

TABLE OF CONTENTS

As will be seen the papers of each member of the Instructing Staff are together, and the groups or blocks of papers are in the order of the names given in the Announcement of the College at the end of this volume.

In each case the original place of publication is indicated.

JAMES LAW, F.R.C.V.S., *Professor of Principles and Practice of Veterinary Medicine, Veterinary Sanitary Science, and Parasitism.*

Address at the Inauguration of the New York State Veterinary College, September 24, 1896.
Reprinted from the Veterinary Magazine, Sept. 1896. Pp. 548-561.

How to Prepare Articles for Shipment to the Pathological Laboratory.
American Veterinary Review, November, 1897. Pp. 547-552.

Report of Minimum Standard of Entrance Examinations.
Proceedings United States Veterinary Medical Association, 1897. Pp. 226-235.

Infectious Diseases Common to Man and Animals.
A System of Practical Medicine by American Authors, Vol. iii, 1898. Pp. 741-784.

Glanders, Pp. 741-752.

Anthrax, Pp. 753-762.

Rabies, Pp. 763-773.

Actinomycosis, Pp. 775-784.

Increased Requirements for the Study of Veterinary Medicine in New York. Answer to Article in Turf, Field and Farm, April 22, 1898. P. 517, and April 29th, p. 552.

Dangers to Mankind from the Consumption of the Flesh and Milk of Tuberculous Animals.
Proceedings United States Veterinary Medical Association, 1898. Pp. 80-96.

The Coöperation of the Various Examining Boards and the Desirability of Establishing an Interstate Examining Board, the Certificate of Which would be Accepted by the Boards of all States.
Proceedings United States Veterinary Medical Association. 1898. Pp. 199-206.

Tuberculosis in Animals and its Control.
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Paper in Country Gentleman, 1898.

Contagious Abortion in Cows.
Report of the State Commissioner of Agriculture for 1898.

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Am. Vet. Rev., August, 1897. Vol. xxi, p. 303.

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JAMES LAW, F.R.C.V.S.,

Professor of Principles and Practice of Veterinary Medicine, Veterinary Sanitary Science, and Parasitism.

ARTICLES.

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Glanders, Pp. 741-752.

Anthrax, Pp. 753-762.

Rabies, Pp. 763-773.

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ADDRESS

AT THE

INAUGURATION OF THE NEW YORK STATE VETERINARY COLLEGE,

SEPTEMBER 24, 1896.

By Professor James Law.

[Reprinted from The Veterinary Magazine, September, 1896.]

It seems desirable to say a few words to you collectively in view of the inauguration of a new enterprise in America—a State Veterinary College. As an English-speaking people we have been especially influenced by English example in shaping many of our institutions, and in none more so than in those to which veterinary education has been committed. It has been a crowning glory of the Anglo-Saxon races that they have suspected and frowned upon a too paternal government. In Europe and America, in South Africa. Australia and New Zealand, a prominent aim has been to restrict the functions of government to the protection of the citizen in his personal rights of property and conscience, in his lawful business enterprises, and his pursuit of pleasure. Education, it is true, came in for a constantly increasing share of national control and support, but this was for long mainly along classic lines, and was a legacy which came down to us from the early monastic and ecclesiastical schools. For purely secular education money was slowly and grudgingly allowed, with a wholesome dread of the evils to be apprehended from class legislation. That instinct of even-handed justice which demanded for the citizen a trial by a jury of his peers, naturally recoiled from any proposition which looked like an appropriation of public money for the creation or benefit of any special class or guild. It is only in recent years that the manifest value to the nation, in its competition with other nations, of the highest knowledge and skill in science and arts, has led to the founding and support of technical and professional schools of all kinds, to keep the country in the forefront of the race of civilization and progress.

As the Anglo-Saxon peoples have gradually awakened to the need of government provision for technical education, those branches which seemed to be of the greatest material value were naturally the first and most liberally dealt with, while those in which the prizes were smaller or the triumphs less striking, and competition less close, were still left to shift for themselves.

In Great Britain there has never been a State Veterinary College, and the four existing schools have been all founded by private enterprise and conducted independently of State grants.

In America, as in England, the veterinary schools have been private ventures, and consequently largely dominated by the financial results. The founders of such schools were met at the threshold by the imperative questions:

Will the venture pay?

Can we secure fees enough to sustain it?

Will the name of the college bring us greater and more remunerative practice?

Will the prospective fees, fame and practice warrant the investment?

The answer is necessarily dominated by the question of money, and the temptation is great to subordinate the educational considerations. The pressure is heavy: 1. To shorten the curriculum; 2. To admit ill-prepared candidates; 3. To graduate large numbers, irrespective of fitness; 4. To further abridge the already short course, and as a final degradation; 5. To sell diplomas.

To this last, lowest depth of sordidness more than one veterinary college in America has sunk. But short of this, even the surviving and honorable colleges have been one and all prevented from achieving the status which the nature of the subject demanded. The preliminary education and the trained mind which are requisite to the successful pursuit of the science, have not been required for matriculation, and the course has been abridged to such an extent that even a trained mind cannot successfully cover the required ground in the time allowed him. Meanwhile the field of veterinary science has been rapidly enlarging, deepening, widening and becoming more thoroughly cultivated, so that the insufficiency of the untrained student and his short curriculum have become more and more marked year by year.

The contrast with the schools of veterinary medicine on the continent of Europe will emphasize this statement. In entering a continental veterinary school the student must show that he has graduated from a *real skule*, *gymnasium* or *college*, and he must pursue a veterinary course of from three years and a half to five years, of nine or ten months each, ere he can hope to secure a degree. Add to this that the great advances in medicine have been such that the great majority of the students have to study one additional year ere they can secure the coveted diploma, and we can appreciate the hopeless inadequacy of a course of two or even of three sessions of five or six months each, which has not been preceded by a mental training in high school or college.

These continental veterinary colleges would have been no more thorough than the English or American had they been dependent on private enterprise. But there is no veterinary college on the continent of Europe today that is not a ward of the government. Each one has been founded and is sustained by the commonwealth just as are the army, the navy, the experiment farms, etc. This paternalism is founded on a long experience of their value, of which I may be permitted to give a single example.

The disease, rinderpest, which confines its ravages to ruminants, and, as its name indicates, almost entirely to cattle, formerly spread over most of Europe at frequent intervals, killing twenty to ninety-five per cent. of the bovine race at a single invasion. Paulet tells us that in Western Europe in three years (1711-14) it cut off 1,500,000 head of cattle, and Faust says that in the whole of Europe in four general invasions dating from 1711, it destroyed no less than 200,000,000 head. At $20 per head this reaches the astounding sum of $4,000,000,000. So late as 1844, according to Raynal, it destroyed 1,000,000 head in Southern Russia alone.

Thanks to the veterinary profession of Europe, this disease can never again attain such boundless sway, and though still extended at intervals in the course of belligerent armies, or in the channels of trade, it is always met with intelligent measures of control and speedily suppressed.

This is but one of the deadly plagues of the Old World, the ruinous extensions of which led, in 1762, to the establishing of the first European veterinary school at Lyons, France, under

the presidency of Bourgelat. This was followed, a year later, by a second school at Charenton, near Paris, and still later by a third at Toulouse. These were succeeded by a score of others in the different countries of the continent, all at the national charge and under government control. They are justly looked upon as economic investments, not only for the restriction and extinction of the plagues, formerly so rife and fatal, but also for the conserving of the lives and efficiency of the horses of the cavalry and artillery; for the protection and fostering of the various animal industries, and indirectly, though no less certainly, for the paramount preservation of the fertility of the soil.

The results have abundantly vindicated the wisdom of the investment:

The protected herds have furnished a cheap and abundant food for the growing populations.

The increasing demand for cattle food, and the multiplying of the natural sources of rich manure, have combined to enrich the fields and improve the crops.

The improved agriculture and abundance of food products, have fostered every branch of manufacture and trade and contributed to a substantial prosperity.

The contrast in countries where veterinary science has been ignored is quite instructive. In South Africa, apart from the mining interests, grazing has long been the main source of wealth. Into this country lung plague was imported in infected Dutch cattle in 1854, and extending on the unfenced grazing tracts, under a semi-torrid climate, proved so disastrous that, according to Lindley, whole herds of 100 or 200 head would perish without a single exception. At that time the Matabele chief occupying land protected on two sides by inaccessible cliffs, successfully defended his passes against the diseased cattle and saved the wealth of his people.

Now, recently, a cargo of cattle from infected Hindostan has implanted the still more redoubtable rinderpest in South Africa, and in the disturbed condition of the country this has penetrated even into Matabeleland and bids fair to destroy the cattle industry of South Africa.

Again, the lung plague, imported into Australia in 1859, in a diseased English cow, was allowed to spread over the whole island continent, and permanently blighted the cattle industry in one of the finest pasture lands on earth.

In England this same lung plague in the forty years succeeding 1842, cost the nation $500,000,000.

In the United States the same plague prevailed in our eastern seaboard States for over forty years, causing losses that have never been estimated, and incidentally leading to an embargo on American cattle in England, which entailed a loss of ten dollars a head on an average to the exporter. This alone amounted to $2,000,000 per annum. It was only when the plague reached the centre of our cattle traffic (Chicago), and bade fair to invade the whole country, including the unfenced Territories, and to repeat in America the experience of South Africa and Australia, that the national and State governments were roused from their lethargy, and we were empowered to take efficient measures for its extinction. Happily now it has no place on this continent, and with reasonable precautions can never make a new invasion.

The same line of thought and similar historic facts could be followed and adduced as to the other animal plagues, including the affections caused by the larger animal parasites; as to enzootic diseases caused by faulty conditions of the environment; as to constitutional diseases, due to errors in breeding, diet and regimen, and as to local diseases, many of which are due to improper treatment.

In America as in Europe we can successfully maintain that the benefits already drawn from the veterinary profession have abundantly vindicated its claim to State support. But the prospective value of the work of veterinary investigation and education far exceeds all that they accomplished for the nation in the past. Among our horses glanders yearly claims a large and valuable sacrifice to its devouring poison. Among cattle, anthrax, tuberculosis, and Southern cattle fever cause widespread though needless destruction. Among sheep, flocks are decimated everywhere by remorseless parasites, internal and external. Among swine the preventable infectious fevers cost the nation on a low estimate 20,000,000 per annum. Among fowls the prevalent contagious affections are no less disastrous.

In the matter of numbers, the wealth at stake in the live-stock of America is as great as that of European nations, and to the reasoning mind, is no less exacting of measures for its protection. In four of the most important countries of Western Europe, the aggregate of the farm mammals is considerably

less than that of the United States. Yet these four countries of Western Europe (France, Belgium, Holland and Germany) have eleven veterinary schools maintained and fostered at State expense. Surely our own Empire State with its 9,500,000 of farm mammals, with its large emporia at Buffalo, Albany and New York, for the reception and diffusion of live-stock from other States, and its record of a recent riddance from a cattle plague, which for over forty years had hung like a pall on the cattle industry of the State, and exacted a tax of $2,000,000 or more per annum from home herds and exports, is fully justified in establishing a State Veterinary College.

But if the more economic advantage would demand such a step, how much more would the protection of human health and life? How much of the physical disease and death of man is due to direct transmission from corresponding diseases in our domestic animals, is only now beginning to be realized.

Among parasites some of the most deadly of man's tormentors came directly from our live-stock. Trichina, echinococcus, the beef and pork tapeworms, strongylus gigas, and actinomycosis may be mentioned in this connection.

Among microbian diseases the list is no less redoubtable. Glanders, farcy, rabies, tetanus, milk sickness, tuberculosis, anthrax, malignant edema, septicemia, erysipelas, gangrene and infectious osteitis, may be adduced as examples.

The more intimately we acquaint ourselves with the subject of communicable or contagious disease, the more deeply are we impressed with the fact that there is the closest relationship and interdependence between these affections as they appear in man and animals. Indeed, in many cases, as in the echinococcus, the beef and pork tapeworms and even the trichina, the successive appearance of man and animal as the host of the parasite, at the different stages of its development, is a condition of its propagation. So far as we know, it is impossible for the echinococcus or of the beef tenia, to live in the same host or in a host of the same genus in both its larval and mature condition. Man harbors the larva and the dog the tenia, or the calf entertains the larva and his master the tenia.

In the case of contagious affections due to microbes, the same alternation from man to beast, and from beast to man, is not so essential to their maintenance, and yet the intimacy of the relation between the domesticated animal and the civilized

man is so close that many such diseases are largely propagated in this way. In this sense glanders and anthrax stand out as largely industrial diseases. The first appears in persons having close relations to horses or to horse products—grooms, coachmen, stablemen, cowboys, soldiers, farmers, horsedealers, knackers, veterinarians, surgeons, tanners, gardeners—whose daily avocations lay them specially open to direct infection. The second is a disease of farmers, cattlemen, shepherds, butchers, tanners, hair and wool-workers.

But neither disease is by any means restricted to these classes. These suffer more numerously, but others suffer in a limited degree, through less direct channels of contagion. And the danger of such irregular transmission is in exact ratio with the number of diseased animals that are allowed to survive in a district. A single glandered animal is a source of no great danger. He may be even used on public highways, but his contact with or proximity to man is necessarily somewhat restricted and the human risk is correspondingly small. But let him have free scope to infect others, and these to infect others in turn, until one can hardly enter a street without meeting an infected animal and having him snort his deadly, nasal discharge over his person, and into one's nose, eyes and lips, and the danger at once becomes imminent. Let glanders be neglected in a street-car-stable until its victims are counted by the score, or on a horse ranch until the diseased mount up into the hundreds, and the danger, first to the caretakers, and second to the general public, is greatly enhanced, and human victims of this most loathsome and deadly disease become comparatively common. Let a grocer, baker, milkman, or other vendor of human food keep a glandered horse and use it in his delivery wagon, and the hands of the driver alternately coming in contact with the virulent discharges and the articles of food threaten to become a very direct cause of infection to his unsuspecting customers.

A single anthrax animal would also be primarily a source of apparently little danger, but when that diseased subject is allowed to contaminate other animals and even susceptible soil, which can retain and propagate the bacillus, the danger to both man and beast is enormously increased. Brought up from the graves, by the rising of the soil-water in wet seasons, or by the intervention of the earthworm or the burrowing

rodent, then dried up and blown by the winds upon the vegetation ; drawn up from wells in the drinking water ; borne along by streams and rivers to new localities ; carried on the feet, and even in the stomachs of vermin, birds and insects, and implanted in the skin by their mandibles and biting apparatus, the bacillus finds many channels of conveyance and numerous modes of infection. Delivered from the butcher's stall into our kitchens, the meat of an anthrax animal is liable to contaminate other food, through knives, forks, plates and other articles, and even to cause direct infection through the resistance of the spore to the heat of cooking.

Of late years the general public has been more exercised over tuberculosis than any other complaint which is common to man and beast. There is doubtless good reason for this. This *white plague of the north*, by far the most deadly affection of man, killing one-eighth of civilized humanity, and attacking one-fourth or even one-third at some period of their lives, is also the most prevalent chronic disease of our dairy herds, and its extension in the human race bears a remarkable ratio to the utilization of the bovine races for dairy products and beef. Piscivorous tribes like the western islanders of Scotland are usually remarkably free from tuberculosis, as are also the native Chinese who are vegetarians. The ruling Tartar race in China, on the other hand, are beef-eaters and largely tuberculous. In Egypt and Algiers in the comparative absence of bovine herds, the great influx of consumptives has not materially deteriorated the health of the native population, while in Italy, Australia, Hawaii and Madeira, where the population freely consume the product of the bovine race, the rush of phthisical health-seekers has led to a great extension of tuberculosis among the natives. Among tribes of our own Indians, who feed on the raw flesh of the ox, too often diseased, 50 per cent of the total mortality is from tuberculosis.

Concurrent testimony obtained on so large a scale, and from such widely different sources, is not to be lightly set aside. Tuberculosis is mostly a chronic disease, frequently lasting through a long lifetime. A certain number of cases recover, many more remain dormant, ready to burst into renewed activity whenever the health is otherwise undermined. It is essentially a "pestilence that walketh in darkness," and often under an outward guise of health, the subject of the disease carries

around the germs of certain death to his unsuspecting and more susceptible fellow. The very latency of the disease in certain systems, and the absence of all prominent outward manifestations of illness, is a potent factor in the propagation of the infection. A disease that is quickly fatal, like smallpox, plague, yellow fever or cholera in man, or anthrax, rinderpest or Texas fever in cattle, is easily dealt with, since wherever the germ exists in connection with susceptible subjects, its presence will be speedily manifested, and it can easily be circumscribed and crushed out. These make their attack in broad daylight as with great sound of trumpet and roll of drum, and we are warned to fortify every pass and strengthen every defense. But the stealthy tubercle bacillus, which glides up in the darkness and silence, and as it were saps our walls of defense without visible manifestation or audible sound, and suddenly appears, when least expected, in the interior of our most trusted keep, is by far the most dangerous enemy.

To neglect our defense because of this subtlety is to abandon our cause and play the poltroon. This is not the part of modern science ; this is not the course of the medicine of today and of the future.

To the biologist who has studied the infinitesimal focus of parasitic life, the subtlety of the germ is but a challenge to meet its inroads by a more effective strategy, to meet its hidden mines by equally able countermines, and to turn an otherwise assured defeat into an accomplished victory.

But in doing this he can never safely abandon the first principles of warfare. He can never neglect a favorable opportunity to reduce the number of the enemy, nor to prevent him from securing reinforcements. Yet this is just the course that is strongly urged in regard to tuberculosis. Because some recover, and because other cases remain long latent, we are urged to let such cases go on in their work of indefinitely multiplying the disease germ, and to attack them only when they become acute and deadly. Acute cases don't live long to propagate the disease; whence then comes the constant succession of cases? Mainly from the latent and recovering ones.

Our own university herd is a standing example of a sound prevention of this infection. Formerly affected with tuberculosis, it has now for a number of years been entirely free from the affection, in spite of many risks, and in spite even of the

presence in the barn, for several months, of a latent and unsuspected case, which had been brought from another herd. Had we left that dormant case in the herd after its discovery, it would in all probability have sooner or latter developed into active disease, and become the source of a new general extension of tuberculosis in the herd.

It is impossible, in a short lecture, to lay down infallible and iron rules for dealing with this, or any similar disease, under all possible circumstances. Special conditions may warrant special measures. In the case of valuable animals, where economic considerations would warrant the supervision, separate herds of dormant cases may be allowed for breeding purposes, if they can be kept carefully apart from all other stock, their milk products denied to man or animals, and all acute cases weeded out from the herd as soon as they can be detected. Above all, if such breeding herd of dormant cases can be subjected to a continuous out-of-door life on the open prairie, where the chances of recovery are highest, and the risk of contagion lowest, they may be made profitable by fattening their healthy progeny for beef, or still more so by the perpetuation of a valuable strain of blood. Under such professional supervision, and frequent testing, the actually recovered animals could in due time be removed from their still questioned companions and restored to a guaranteed herd.

But the one who would argue from this that the actual though somewhat latent and dormant cases should be left in the herd that has been tested and proved to be above suspicion, is but pleading for a free field for the propagation of the contagion. The acute cases that would develop at intervals would entail new victims, no longer among the latent cases and suspected animals only, but among the tested and sound as well.

Under average condition, with low-priced cattle, and a State indemnity, the slaughter of all the tuberculous would be the course of economical and successful sanitary work, and when special conditions rendered another and less radical resort permissible, it should only be adopted when hedged about by such precautions as would obviate danger to man and beast.

We know enough about the dreaded tuberculosis to say that we can deal with it successfully under the most varied conditions, but our past achievement does not imply that we have as

yet reached the limit of possible success in this disease; and a similar success in a State or nation would not warrant us in saying that no better measures can be taken. Such a conclusion would be utterly unscientific and unduly conservative. It is the best at present known to us. But in these days when knowledge advances in leaps and bounds, no one can say what tomorrow may have in store for us. Some as yet unknown Edison or Tesla may be even now preparing a surprise in the revelation and utilization of natural forces of which we little dream, and which may cast into the shade our steam engines, our electric telegraphs, telephones, phonographs and skiagraphs.

So in the field of biology and modern medicine. The largest hopes and the brightest ideals are likely to prove the most scientific. The vivid imagination and the scientific foresight must unite to help in our future progress. Not in the case of tuberculosis alone, but in connection with the entire field of medicine, a whole phalanx of possibilities big with promise for the future of humanity confront us.

As biologists we see genera, species, and even varieties of animals that are largely insusceptible to this and that deadly disease. It is for us to grasp the cause of this immunity, and if possible to render it available over a wider area.

As bacteriologists, we recognize incompatibilities and antagonisms between the living cells of the animal body and their products on the one hand, and the pathogenic microbe and its products on the other. How far can we avail of these to strike a balance favorable for and productive to the animal? We are as yet on the mere confines of this great science of bacteriology. In the vast microscopic world full of attractions and repulsions of living cells and microbes, of neutralizations, and physiological antagonisms of leucomains, ptomains, toxins and enzymes, of sozins and phylaxins, there are many and bright promises for the future of preventive and therapeutic medicine. But it is only the trained mind rich with the knowledge already attained in this science that can hope to achieve the triumphs of the future. Knowledge, skill, imagination, sound judgment and indefatigable industry, must combine in the man who would hope for success in this field. It is no place for the dull or the laggard.

Without undue arrogance it may be asserted that to us has been allotted a large measure of responsibility in relation to this

work. By the generosity of the Empire State we are enabled to enter on the field. We have been furnished with the nucleus of a scientific institution from which large and important results may fairly be expected. We are honored as being in a sense the pioneers in a comparatively new field, we have the place of advanced guard in the inevitable warfare. Though small in numbers, our chosen battlefield is one in which numbers count for less than quality, and in respect of quality we have to prove ourselves. Let us take as our primary thought the Socratic aphorism: "Knowledge is virtue: ignorance is crime." In our case this is preeminently—I may say painfully—true. As the beneficiaries of the State, we shall prove unthankful and unworthy if we fail to make the best use possible of its bounty. As trusted representatives of science, it is expected of us that we fortify ourselves with the lore of the past and strike out with clear vision, steady foot and strong hand for future achievement. To rest satisfied with any knowledge short of the best of today, is to neglect our opportunity and prove untrue to our trust. The lore of the past can never be safely set aside, nor entirely ignored. Yet this has led up to so much that is more recent, clearer, more definite, and full of so much greater potencies, that with Socrates, we may say it is criminal to neglect even its smallest lessons. The accumulated knowledge of the ages is great and indispensable, but is small indeed unless we build upon it the riper fruits of its own modern development. This is true for teacher and student alike, for are we not all students in one common school? Some of us may have advanced to a higher grade, while some are but entering the lowest class, but success will crown each only as he devotes his best energies to his work in the spirit of truth, and with the ardor of the enthusiast.

In this, as in all else, we must approve ourselves as men. The veterinary profession has long suffered from the low appreciation in which it has been held. Every one who has conceived an attachment to animals, has thought himself competent to deal with their diseases. Our State is crowded with men who, without further preparation or fitness, have been legally established as veterinarians by a simple registration of their names as such. To the future graduate it is given to redeem the profession from this low public estimate. He must everywhere approve himself first as a man of character, a good man and a

good citizen. Next he must approve himself as a man of science. His judgment and his word must be authoritative on all matters that involve his profession, and the great interests connected with animal industry. He must be an educator in the highest sense. Wherever his lot may be cast, with whatever class of domestic animals he may be called upon to deal, he must charge himself with the task of bringing to the work the accumulated knowledge of the centuries, and especially of the wonderful century which is drawing to its close.

Some of you may be called upon to engage in the extinction of animal plagues. In this, spotless integrity must be joined to the highest knowledge and skill, and conjoined to a deep insight into human nature, and an inflexible purpose of applying even-handed justice, if you would escape the danger of being overwhelmed in the storm of detraction and misrepresentation that will inevitably assail you. The honorable prize to be won is a great one, but it requires a good soldier and a sterling man to bear the brunt. When the complete triumph comes, you will find that your whilom detractors, who have opposed you in perfect good faith, will come forward to acknowledge their error and endorse your achievement. Some will be called to inspect markets and food products, and here with the weighty responsibility of a city's health on your shoulders, you will bless the day that brought you through the vigorous studies of anatomy, physiology, histology, pathology, toxicology, and enabled you with scientific certainty to endorse the wholesome and condemn the diseased and unwholesome.

Some I trust will be called to fill chairs of comparative pathology and comparative medicine now for the first time being established in the most forward medical schools, and which must soon be provided in all such schools that are worthy of the name. None can fill such a place so well as the man who has profoundly studied the special diseases of animals, and indeed none other is fitted to do justice to such a chair. Ever since Hippocrates, the most advanced physicians have recognized and employed the lower animal as a means of advancing medical knowledge. Our knowledge of physiology largely consists in deduction from experiments made on the lower animals; our acquaintance with the physiological action of drugs and poisons very largely consists in accurate observations made on the lower animals; pathology, surgery and

medicine owe much—very much—to the same source; and bacteriology is essentially based on experimentation on the beast. Comparative medicine, therefore, can be best pursued by the veterinarian, who, otherwise equally well furnished with the medical candidate, adds to his accomplishments a thorough practical knowledge of all animal diseases. This will quicken his insight into pathogenic causes and the significance of morbid phenomena, will protect him against hasty and erroneous conclusions, and will make his work at once more productive and more reliable.

Others will be called to undertake investigations in our agricultural experiment stations, where the same wide and accurate knowledge, the same keen insight and skill and the same scientific methods, can alone bring out valuable results.

For all such future fields of usefulness you must now make ample and thorough preparation. Patient labor, earnest and systematic effort, daily accomplishing of the day's problems in a thorough manner, will make the work easy, and assure success.

In entering this institution you begin in a very special sense your work of life. Outside of the professional school the work of preparation has been essentially general and introductory. In the professional college you start upon what you have especially chosen as your life's work.

We who are somewhat older in the field are appointed to advise and guide you in the preliminary stages. It is our purpose and hope to do our whole duty by you, in the right spirit. We bespeak your earnest effort to do your whole duty by the subject in hand, so that the foundations, at the laying of which we mutually labor, may grow up into a grand, noble and worthy development—an honor to your alma mater and to our benefactor the State of New York.

HOW TO PREPARE PRODUCTS FOR SHIPMENT TO THE PATHOLOGICAL LABORATORY.

By James Law.

From the American Veterinary Review, November, 1897. Pp. 547–552.

The work of a pathological and bacteriological laboratory is often very sadly handicapped by the unsatisfactory condition in which morbid specimens reach it, and it occurs to me that it might establish a better relation between the practitioner who feels his need of laboratory assistance on the one hand and the laboratory expert on the other, if some plain instructions for the preparation and shipment of morbid products were furnished to the former. As specimens are usually received they are too often in a condition which renders them absolutely useless for pathological purposes, or, failing this, they demand such an outlay of time, labor and material in order to trace out the nature of each microbe present that it is prodigal in the last degree to attempt such a work. Many specimens reach the laboratory in a condition of advanced putrefaction, in which it is folly to search for the germ of a specific disease or the features of a definite lesion. Others are smeared with filth from outside the body of the animal due to contamination by contact with knives, hands, skin, manure, earth, foul water, and other impure sources, so that, even in the absence of advanced sepsis, the multiplicity of bacteria present demands a long and exhaustive investigation before reliable results can be obtained. In other cases the ferment-laden contents of internal organs, such as the stomach or bowels, become mingled with the bacteria which were at first present in the diseased organs, which have been packed with them, rendering bacteriological work tedious and costly, even if possible at all. In still others the sender has taken precautions against the putrefaction of the product by steeping it in strong alcohol, carbolic acid solution or other antiseptic, and has thus effectually prevented any bacteriological cultures of the more delicate disease germs. It would be easy to add to this list of examples of how not to do it, but it will be more profitable to turn to methods by which the sender can place himself in harmony with the subsequent work of the bacteriologist and pathologist.

1st. Select a case in which the disease is fully developed and in active progress. At the outset many infectious diseases are strictly local affections, and the *materies morbi* can at this stage be found only in such local centre, and the internal organs which are the usual seats of affection are still germ free. Again, in the advanced stages of a purely contagious disease the microbe may be no longer present, while the structural changes caused by it and its products are still sufficiently well marked.

2d. In localized infection take the tissues which bear the local lesions.

3d. In selecting tissues which bear the local lesions, take by preference such morbid conditions as are recent yet well developed, and avoid such as have manifestly a complicated infection. It is a common thing to find tubercle, anthrax and other lesions complicated by the presence of pus organisms and other microbes, and in such cases the search for the primary germ of the disease is correspondingly complicated and difficult.

4th. Take the material from a subject which is newly killed or has died only very recently. In certain diseases septic microbes from the skin, bowels or some other mucous surface, or which are already present in the circulating fluids, are propagated with great rapidity, so that in a very few hours specimens are almost useless for examination or cultures. This is especially true of the warm season and southern latitudes.

5th. When the infection is generalized, aim at securing one or more parenchymatous organs which are likely to contain an abundance of the pathogenic microbes with few or none of the extraneous or saprophytic ones. As example of such organs may be named the liver, kidney, spleen, lymph glands, heart and lung.

6th. In securing the morbid specimen, first clip the hair from the surface of the body where the incision is to be made, then wash it clean with soapsuds, followed by a mercuric chloride solution, 1:500. Wash the hands and disinfect them in the same way. The knife and forceps to be used should be cleansed and placed in, and taken direct from the carbolic acid solution. If greater security is desired they may be dipped in absolute alcohol and burned off.

In case of a superficial local infection, the infected part may be seized with the sterilized forceps, cut with the sterilized knife, and transferred to and wrapped securely in a white cloth thoroughly wrung out of the mercuric chloride or carbolic acid solution, care being taken that it is not allowed to come in contact with any other object.

If an internal parenchymatous organ is desired, an incision is made through the skin, along the ventral aspect of the body from the pubis to the sternum, or the chin, and the skin is dissected back on each side. Then with sterilized knife and, if necessary, bone forceps or saw, the abdomen and perhaps the chest are laid open, so as to expose the organ or organs desired; great care must be taken to avoid wounding the stom-

ach or bowels. Then, with sterilized hands the organ may be seized, cut out and wrapped in a cloth wrung firmly out of a sublimate solution, as already advised. It may then be wrapped in paraffin paper, or in extra cloths wrung out of sublimate solution, and packed in a scalded jar, or in a box with cotton batting, salt, sawdust, wheat-bran, or charcoal for shipment. In all cases in which the organ is small (kidneys, lymph glands, pancreas, etc.,) it should be sent uncut and unmutilated. In large animals in the case of the lungs, liver, spleen or other large organs, a portion only will usually be sufficient, choice being made of a diseased portion. The excision of such part must be made with sterilized instruments, and the cut surface may be allowed to bleed, and may then be scraped with a sterilized knife before wrapping.

7th. When it is desired to send liquids like pus, blood, or liquid exudation, wash and disinfect skin, hands and knives, as already prescribed, provide a bottle and cork that have been thoroughly sterilized by boiling, incise the sac or infiltrated organ and receive the liquid into the bottle direct. Cork and seal. A still more accurate method is to provide small glass tubes that have been sterilized by heat, and drawn to a point at each end and hermetically sealed, so that a vacuum is left internally, having disinfected the surface and incised the sac with a sterilized knife, one end of a vacuum tube is pushed into it, and its point is broken off by pressure against the inner surface of the wall of the sac, when it will instantly fill itself with the contained liquid. It is then withdrawn and hermetically sealed in a gas or alcohol flame, or if nothing better can be had, with melted wax.

8th. To send a portion of diseased intestine, wash it out carefully with boiled water that has been allowed to cool, tie the ends, and enclose in a preserving or other jar, thoroughly sterilized by boiling. If the contents only of the bowels are wanted, they may be placed in a sterilized bottle or jar, and secured with sterilized sealed cork or cover; whenever bottles or jars are used careful packing is necessary to prevent breakage and loss of the material.

9th. In case of a body, which has been opened without any special precaution, and in which lesions suggestive of infection are found, the organ showing the lesions may be washed in a succession of waters that have been boiled and cooled again, and it may then be wrapped in a mercuric chloride cloth and packed for shipment.

10th. In sending the heart, it is important to retain the blood, and all vessels opening into it should be ligated before wrapping.

EXAMPLES OF DISEASES AFFECTING THE DIFFERENT ORGANS.

In the following list, the organ named is likely to be a seat of infection or infestment in the diseases named in connection with it:

Liver.—Anthrax, hog cholera, contagious pneumonia in the horse (brustseuche), omphalo-phlebitis, infectious hepatitis, entero-hepatitis of

turkeys, infectious leucæmia in fowls, fowl cholera, Southern cattle fever, hepatic tubercle, actinomycosis, tumors, gall stones, distomatosis, echinococcus, cysticercus, tennicollis, tænia fimbriata, nematodes, etc.

Spleen.—Anthrax, Southern cattle fever, swine plague, hog cholera, contagious pneumonia, splenic tubercle, actinomycosis, sarcoma, carcinoma, glanders, etc.

Kidneys.—Anthrax, infectious nephritis, hog cholera, fowl cholera, Southern cattle fever, pyæmia, septicæmia, calculi, strongylus gigas.

Lungs.—Contagious pneumonia (horse), lung plague (cattle), influenza, contagious broncho-pneumonia (cattle), canine distemper, swine plague, aspergillis, pneumonia (fowls), pulmonary glanders, actinomycosis, anthrax, pulmonary lesions of petechial fever, pulmonary acariasis, pulmonary helminthiasis.

Stomach or Bowels.—Hog cholera, swine plague, fowl cholera, dysentery, contagious diarrhœa and muco-enteritis (Calvisk), milk sickness, intestinal anthrax, tuberculosis, actinomycosis, tumors, parasites, etc.

Lymph Glands.—Anthrax, tuberculosis, glanders, strangles, swine plague, hog cholera.

Brain or Spinal Chord.—Rabies, dourine, cœnurus, cerebro-spinal meningitis.

Heart.—Anthrax, milk sickness, swine plague, hog cholera, contagious pneumonia, influenza, petechial fever, ulcerative endocarditis, etc.

Womb, Fœtal Membranes.—Contagious abortion, infectious metritis.

Milk.—Contagious mammitis, aphthous fever, milk sickness.

Udder, Mammæ.—Contagious mammitis, affecting ducts and follicles, cow pox.

Saliva, Bronchial Mucous.—Rabies, contagious pustular stomatitis, aphthous fever.

Jaws, Buccal Mucosa.—Thrush, contagious pustula, stomatitis, aphthous fever, pseudo-membranous inflammation, actinomycosis, tumors.

Pharynx.—Anthrax, tuberculosis, pseudo-membranous and infectious inflammations, glanders, etc.

Local Lesions.—In certain diseases the lesions are localized in particular parts or in the seat of inoculation, and such part must be secured, wrapped and shipped with all antiseptic precautions. Thus we have the connective tissue and muscles affected in emphysematous anthrax, malignant œdema, and other infective local inflammations, etc. The skin in cow pox, ringworm, acariasis (mange). In tetanus the bacilli are rarely or never found except in the seat of the wound.

In all generalized infectious diseases, it is important to ship several diseased organs or parts of organs, thereby rendering the discovery of any pathogenic micro-organism much more probable.

REPORT OF MINIMUM STANDARD OF ENTRANCE EXAMINATIONS.

By James Law.

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In approaching the question of matriculation examination we are confronted by two considerations which are essentially antagonistic in their natures.

First. For the great body of veterinarians the emoluments of the profession are often too small to warrant a great outlay of time and money in preparing to enter it; and the man who has spent his early life in some occupation connected with the care of animals, has acquired a special aptitude in handling and caring for them, but has rarely the means requisite for an extended course of study.

Second. On the other hand the lack of preliminary education places a handicap on the efforts of the candidate not only during his college career but during his whole subsequent professional life. The nomenclature is for the ignorant a meaningless jargon with which he must struggle laboriously, word for word, without one ray of philological light to help the jaded memory. In the modern class, say of chemistry, he is called upon to face and solve problems for which a knowledge of mathematics is an essential prerequisite. In pathology and bacteriology, without which there can be no scientific medicine, he must lay the foundation of a knowledge of the microscope for which physics is indispensable. In materia medica, if ignorant of botany, he must fail to grasp and utilize the families, orders and genera which furnish a key to physiological and therapeutical use.

If he knows nothing of geology he is debarred from the intelligent study and prophylaxsis of enzootic diseases, due to mineral impregnations of water and food, or to the propagation of given fauna or flora, and the diffusion of given organic poisons, on particular formations. Turn where we will, we find the way barred to the candidate who is unprepared or

poorly prepared, and open and inviting to him who comes armed and furnished.

A no less important consideration is this, that the mind that has been already trained to habits of study and reasoning has capacities to which the untrained mind is an entire stranger. From a long experience in teaching students in the different years of their university curriculum, from the first to the fourth, students who had all entered under the test of a severe matriculation examination, I have learned that *cæteris paribus*, the students of the third and fourth year were far superior to those of the first and second. I have also learned that those who have entered as special students without matriculation examination have in their turn fallen far behind the students that entered by such examination, and too often they have been compelled to relinquish their efforts and drop out of the University without even completing a single year of study.

I speak now of the rule, not of exceptional cases. Two men of equal mental capacity as a native gift, coming to the same task, with minds respectively disciplined and undisciplined, meet with success and failure, in accordance with the measure of such previous discipline.

The exceptionally brilliant man is likely to succeed in spite of every obstacle, to grasp readily what is beyond the reach of the common mind, to learn how best to secure for himself the preliminaries, that will enable him to deal with the more difficult problems, and increasing his mental strength by patient, earnest, and well directed effort, he may distance those who started with far better preparation, but without his mental capacity. But even he would have done better work if he had accomplished this preliminary study before he entered on his college course. His whole energies could then have been expended, intelligently, from the first moment, on his professional studies and the same mental outlay would have secured a double or treble return.

The great majority of our students are not men of genius, and it is a poor economy to sacrifice the great body of the rank and file, because one great genius can afford to dispense with certain stepping stones to success, or rather can find for himself the stepping stones which we should have provided. The time lost even by the genius in finding and placing the stepping stones has lost to him, for the time being, much that he should have been free to garner at once.

But, it may be claimed, the supposed genius could not possibly secure both the necessary school preparation, and the professional education. He would have been lost to the profession if the preliminary education requirement had been enforced. On the other hand it may be argued that if he had not the courage to face the preliminary work in the regular way, he showed himself to be lacking in that virtue of perseverance which is so essential to success in after life, and if so, even his exceptional powers in other directions might fail to compensate for the fundamental defect. It is easier for him to take these preliminary studies under experienced

teachers, than to dig them out alone with many a blunder and stumble. The exceptional man may fit himself for veterinary practice without the aid of a college at all, but none of us would advocate such a course on the ground that he has neither means nor leisure. As teachers it is our duty to provide the education which is best all round, for the average candidate first and for the man of extraordinary ability as well. We cannot afford to sacrifice the average man, to the possibilities of the genius, and we cannot afford to dwarf even the genius, because under unfavorable conditions he can compare favorably with the average.

Choose what course we will, we shall turn out a large number of men of common powers, and occasionally one of unusual ability. The question with us must be: What is best for the future of the profession, and for the great live stock and national interests involved in this? Can we secure and hold the confidence of the general public and of the government by turning out a large body of men who will do the profession meagre credit, and delay the time when they will take their true position in the fields of sanitation and medicine? The sister profession has generally taken the position that an educated and disciplined mind is essential to the study of medicine. We have an even wider field than theirs and if we lag behind, and act on the assumption that a mere superficial training will suffice for the medicine of the lower animals, can we blame legislators if we find what is essentially veterinary work entrusted rather to the medical profession. Few members of the medical profession are at all fitted to deal with the diseases of animals, but if the legal requirements for that profession are a well educated and disciplined mind, and a thorough course of medicine, it must not surprise us if the lawmakers entrust veterinary sanitary matters to the disciplined and accomplished profession of medicine, and refuse to entrust them to the comparatively undisciplined and unaccomplished profession of veterinary medicine.

Even for medicine this legislation for preliminary education and discipline is new, and the great body of existing physicians, is in no sense guaranteed by it, but the very fact that this demand is on the statute book reflects on all and furnishes a general standard which is by no means justified by the facts. The medical fraternity which has come down to us from the past, profits by the assured legal status of the medical graduates of the future, and if we would hold our own proper place in public estimation, we too must see that our profession has provided for a similar advance. To impose the duties of the veterinary sanitarian on the physician is a great wrong to the community, and it is little to the credit of some members of the medical profession that they cling tenaciously to offices which they are by no means fitted to fill, but on the other hand, if we would aspire to do our full duty to the people, we must furnish the men who in mental discipline, in profound pathological training and in special veterinary skill, are fully competent to deal with the questions involved.

Our delinquency in this respect tends to undermine the success of the medical man who trenches on our special field, for he has always to fall back on the veterinarian to do the actual practical field work, and in proportion to the inefficiency of the latter will be the inefficiency of his superior. But in such a case the odium falls necessarily and justly quite as much on the veterinary as on the medical profession, for whatever may be the shortcomings of the medical chief, they must attach also to the veterinary representative in the field, and these the latter must bear in addition to all his own personal faults and failures. In the same way an inefficient worker in the field must negative to a considerable extent the best direction received from a veterinary chief so that in any case to insure success we must have our veterinarians thoroughly educated in order to accomplish satisfactory work.

This seems to be much better understood by the veterinary educators of the Old World. To satisfy myself on this point, I have placed side by side the matriculation demands of the European and American Veterinary Colleges, and I must say that the exhibition is not at all calculated to flatter our national pride.

In EUROPE the candidate for matriculation must meet the following demands :

In *France*. He must be bachelor of letters or sciences, bachelor of special secondary education, or a graduate of a national school of agriculture. If a special examination is called for it includes the elements of physics, chemistry, botany, zoology and geology.

In *Germany*. He must furnish a certificate of admission to the highest professional class of a gymnasium, or to the highest Latin one, or an official certificate of a full equivalent. (Latin is obligatory).

In *Austria*. He must have passed the first six classes in a gymnasium (the whole course is eight classes), or as an equivalent he must pass in German, physics, chemistry, natural history, geography, history, and algebra.

In *Russia*. He must have passed the first six classes in a gymnasium ; or the full course in a seminary or professional school. (Latin always obligatory).

In *Italy*. National literature ; algebra ; elementary geometry and physics ; or the license of a lyceum or technical school.

In *Spain*. Arithmetic, algebra and geometry.

In *Portugal*. Portugese, French, Latin, arithmetic, physics and chemistry.

In *Sweden*. The first six classes in primary education.

In *Hanover*. Certificate of admission to an advanced Latin school, a first-class professional school, or a seminary. (Latin obligatory.)

In *Denmark*. Danish and two other tongues (English, French, German), mathematics, physics and natural history.

In *Holland*. Dutch, German, French and mathematics.

In *Switzerland*. French and German (or a second living tongue), Latin, geography, mathematics, natural history, physics and chemistry.

In *Hungary*. First six classes in a gymnasium, Hungarian, mathematics, natural history.

In *Belgium*. Flemish; the degree of an university, or of a normal school, or of a course in arts, or of an atheneum, or of a state commercial college, or sufficient to admit the candidate to the special schools connected with an university or state military school.

In *England*. English, arithmetic, geometry, algebra, history, Latin, and one of the following: Greek, French, German, Italian or Spanish.

In AMERICA the demands are as follows:

In *New York*. A four year high school course representing forty-eight regent's counts.

In *New York State Veterinary College*. A four years high school course, or English, geography, physiology, plane geometry, algebra through quadratics, United States history, and any three of the following: Latin, Greek, French, German, physics, botany, geology, vertebrate zoology and invertebrate zoology.

In *Ohio State University, Veterinary College*. a. For veterinary surgeon: arithmetic, geography and grammar. b. For doctor of veterinary medicine: arithmetic, grammar, descriptive and physical geography, English composition and rhetoric, history, Latin, physics.

In *Harvard Veterinary College*. English branches and one of the following: Latin, French and German prose, plane geometry and zoology.

In *The University of Pennsylvania Veterinary Department*. English grammar, orthography and physics.

In *Iowa State Veterinary College*. English grammar, orthography, arithmetic, physiology and United States history.

In *McGill University, Veterinary College*. Orthography, arithmetic, geography, English composition.

In *Kansas City Veterinary College, McKillip's Veterinary College* and *United States College of Veterinary Surgeons*. The education required by the Association of American Veterinary College Faculties.

In the *National Veterinary College*. The ordinary branches of an English education.

In the *Veterinary Department, Detroit School of Medicine*. English branches.

In *Chicago Veterinary College* and *Indiana Veterinary College*. Common school education.

In the *University of California, Veterinary Department*. A written examination; scope not intimated.

In the *Ontario Veterinary College* and the *Ohio Veterinary College, Cincinnati*. Reading, writing and spelling.

The only American examples which at all approximate to the

European Colleges are those of New York where a four years high school course is now demanded by law, and the Ohio State University, College of Veterinary Medicine, which for its veterinary doctorate demands, arithmetic, grammar, descriptive and physical geography, English composition and rhetoric, history, Latin and physics. To some extent the Ohio school amends this honorable standard by offering the degree of veterinary surgeon on a matriculation in arithmetic, geography, and grammar only. With a veterinary degree of this university to be obtained on this lower plan, it would not be wonderful if the candidates for the higher degree were few and far between.

The contrast between the requirements in the European and American schools becomes still greater when we consider that the college curriculum in Europe is almost invariably one of four years of eight or ten months each, while most of our schools have just adopted a three year course of six months. Five only of our American colleges, Harvard, Iowa, Ohio, New York State Veterinary College and Pennsylvania, have an academic year of nine months. For the remaining eleven the whole curriculum covers but eighteen months as contrasted with the thirty-six months standard of the European schools. Even our five *advance guard* schools with their three years course of nine months to the year, represent but three-fourths of the curriculum of the European schools. And outside New York and Ohio, the preliminary requirements bear no ratio to the demands for matriculation in Europe. The one American college which in its requirements will bear comparison with the European is the New York State Veterinary College. Its matriculation examination is more exacting than that of the Royal Veterinary College of London, but its curriculum is still five months short of that of the London school. If it shall attain to its coveted four years course, it will exceed that of London by four months, and may then claim to stand as the equal of any school of the world.

These facts are not adduced in any invidious sense. They are, however, germane to the question before us and that question cannot be solved in any satisfactory way without looking these facts squarely in the face.

If our college curriculum is far short of that of the European veterinary schools, we cannot afford to add to its inferiority, by seeking to defeat any attempt at improving the wofully inadequate matriculation examination. If we cannot at once extend our curriculum in the direction taken by the European schools, we can at least raise our matriculation requirements so as to secure the best results from our confessedly too short curriculum. It is impossible to grade down, we must henceforth grade up. If, for example, the graduates of schools outside New York wish to practice in the Empire State they must see to it that their alma mater has had a matriculation representing four years of academic work equal to that demanded by the regents of the high schools of New York, and that this has been followed by three years of professional study equal

to that demanded in the veterinary schools of New York. To admit practitioners from other states, would be to place a premium on the lower requirements, to aim a deadly blow at the New York State schools, and to foist upon the stock owner of New York, veterinarians of a less educated class, when the statute provides that they shall have the best. New York cannot recede from the position she has assumed. Any such proposal will be successfully resisted by the veterinarians and stock owners of the state. The legislature could not think of such a thing as it would be a direct act of hositility to the veterinary colleges of the home state and to the high status to which the statute holds them.

The same remark applies to any other state which requires a higher standard for its veterinary practice than that of adjacent states. To hold its own native practitioners or graduates to a high standard, and to admit practitioners from outside on a lower standard would be to the last degree unpatriotic and injurious. The state must either have no law regulating the practice of the profession or it must apply such a statute with inflexible justice, and above all, it must not administer it in favor of the alien as against the citizen.

The difficulty of an equitable adjustment comes from the fact that we are a federation of independent states. Congress cannot impose on the states a common standard of veterinary education and practice. The only harmony attainable must come from the adoption of a common standard by the different state licensing bodies, and by an agreement of such official bodies to accept at their face values the licenses granted under government authority in the sister state. To do more than this would be to shatter at one blow the superstructure which has been laboriously secured in the different states for the elevation and improvement of the veterinary profession, and to restore the chaos and confusion of fifteen years ago.

So long as the requirements in the different states vary as much as they now do, the best that can be done will be to let the states arrange themselves in groups having parallel requirements, and let the licenses granted in any one state be accepted in all the other states belonging to the same group, while if any practitioner should desire to practice outside the states of his own particular group, he must accommodate himself to the standard of the state of his adoption, and if that standard is higher than in his former home, he must meet the extra requirements, or forego the desired change

The only possible minimum requirement which will entitle to a license to practice in all states alike, is the highest standard set in any one of the federated states, and to secure a common standard all must reach up to that level.

INFECTIOUS DISEASES COMMON TO MAN AND ANIMALS.

By James Law.

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GLANDERS.

Pp. 741-752.

Synonyms.—Malleus; Equinia gravior; Farcy.

Definition.—An acute or chronic infectious disease attacking the lymphatic system, especially of the upper air passages or of the skin, and characterized by a progressive hyperplasia with a strong tendency to degeneration and ulceration. As affecting the skin it is usually known as *farcy*, whereas in the deeper organs it is known as *glanders*. The combination *farcy-glanders* is usual in acute cases.

Animals susceptible.—This is especially a disease of solipeds (horse, ass, mule, etc.), but is inoculable on most mammals (excepting those of the genus Bovis) and on the human being. In addition to bovine animals, the house- and the white mouse, the rat, the hen and the linnet prove refractory. Sheep, swine, and pigeons can be inoculated, but not with certainty. The ass is especially susceptible and contracts the disease in its worst form, so that it is usually selected for test inoculations. Next to the ass the guinea-pig is the most serviceable. White and house mice are insusceptible to glanders, but are susceptible to strangles, whereas field mice are susceptible to glanders, but insusceptible to strangles, thereby affording a means of distinguishing these two affections. Glanders inoculated on the dog advances for eight to fifteen days; then the ulcer becomes stationary for one or two weeks, and ends by cicatrization and complete recovery. In the cat death may arrive in two weeks, with articular lesions. The virus has been found to be less potent on other ani-

mals after several passages through the cat (Zakharoff), whereas its potency was enhanced by passing through the pig or lion (Gamaléia, Trasbot).

Geographical Distribution.—Glanders exists in the greater part of the civilized world, whether in the eastern or western hemisphere, but its ravages are greatest in the temperate zones, where enterprise is most active and the movement and sales of horses are the most numerous. Thus in Norway there are but six cases yearly for 100,000 horses, in Belguim 138, and in France until recently 1130 (now 42). In the United States it seems to have been largely confined in the Northern States before 1861, but spread over the South in connection with the war. Mexico it is said to have entered with the American cavalry in 1847. Similarly Portugal is said to have been exempt until the Napoleonic invasion in 1797. Central Hindustan was said to be free from it until the war with Afghanistan in 1878. In all these cases the movements of cavalry and artillery and of commissariat trains spread the affection widely. In our own case the sales of horses and mules at the close of the war produced a very general diffusion from which we are still suffering.

Insular places escape, especially if far from the main land and free from importation of horses. Thus glanders is very rare in Iceland and the Faroe Islands, with 35,000 horses, and in Bornholm with 7,000, while in Australia, Tasmania, and New Zealand it is unknown.

Etiology.—The one essential cause of glanders is the *bacillus mallei*, a small rod-shaped body in length about one-third the diameter of a red blood globule.

Though this germ is most abundant in the tissues of the neoplasms, and in the discharges from the open abscesses and ulcers, and especially those of the nasal and pulmonary mucosa, yet no vascular tissue of the body possesses an immunity, and infection has been conveyed by transfusion of the blood of the badly affected glanderous animal, as well as by the mucus, tears, saliva, sweat, urine, and milk. It has been transmitted by coition, and from mother to fœtus, even when no apparent disease of the placenta existed. Many failures, however, occur when these natural secretions are inoculated.

Infected secretions, and above all the discharges from the specific sores, may dry upon any solid body and be transmitted by mediate contagion, or as dust they may be carried on air currents and infect animals at a distance. Among the common channels of mediate contagion may be mentioned the racks and mangers in livery stables and public feeding places, public drinking troughs, buckets, harness, clothing, combs, brushes, rubbers, solid food, litter, the hands and clothes of attendants, poles of wagons, etc.

In addition to such accessory causes must be named all those conditions of life which increase the susceptibility of the animal. While there is undoubtedly a variable susceptibility in different horses and other soli-

peds, yet in all the main sources of increased susceptibility are to be found an impairment of the general health and vigor. All chronic and exhausting diseases predispose, so that before the discovery that glanders arises from infection alone it was thought to be the winding up of all wasting and debilitating disorders in the horse. Similarly, debility from low feeding and overwork has often been shown to be followed by a great extension of the malady, while a better diet and regimen reduced the number of cases. Dark, damp, and cold stables have similarly determined a great increase of cases, which diminished with sunshine, warmth, and dryness. Finally, impure air, and especially such as has been breathed repeatedly and largely robbed of its oxygen, is perhaps the most potent of all accessory causes. In the British military expeditions prior to 1868 the cavalry sent by sea and often battened down during storms, were usually decimated by glanders or worse. Since that date, with the rigid exclusion of glandered horses from this arm of the service and the purifying of the transports, escape has been the rule. Prior to 1836 the French cavalry stables were very badly ventilated, and glanders carried off 140 per 1000 horses yearly ; at that date improvements mainly in ventilation reduced this loss to 34, and later still further improvements lowered the glanders losses to 2. In close stables, and especially cellar stables, any existing glanders spreads quickly and in its worst forms.

Bacillus Mallei.—This was described and figured by Christol and Kiener in 1868 as a chain of globular bodies in a common sheath. In 1881-82, Bouchard, Capitan, and Charrin in France and Löffler and Schütz in Germany investigated and demonstrated the germ by cultures and otherwise. The early work of Kitt and Weichselbaum was no less important.

The germ is rod-shaped, 2 to 5 μ long by 0.5 to 1.4 μ thick, or about the length of the *bacillus tuberculosis*, and a little thicker. It grows thicker, and even somewhat shorter, in liquid cultures, still more emphasizing the difference. The germs also differ widely in their susceptibility to stains and bleaching agents. The glanders bacillus stains more speedily than that of tuberculosis, especially in alkaline solutions, and it parts with its color in acids far more quickly.

The *bacillus mallei* is aërobic (facultative anaërobic), non-motile, and parasitic. It grows, however, in many nutrient culture media, and notably in glycerin agar or on potato, forming on the latter long filaments. The best temperature for culture is 37° C., and it will not grow below 22° C. nor above 42° C. On agar in forty-eight hours it forms a dense opaque milk white layer, changing later to yellow and brown.

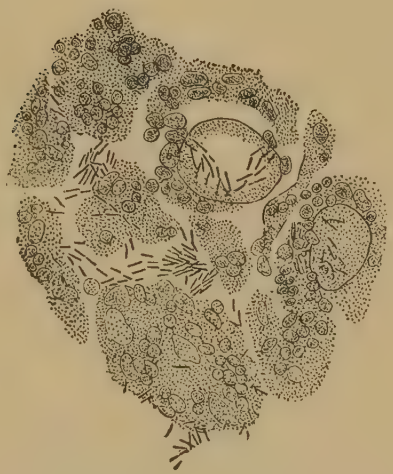
Its vitality is destroyed by a temperature of 100° C. for two minutes, or of 55° C. for ten minutes (Löffler). It is devitalized by corrosive sublimate (1 : 5000) in two minutes ; by permanganate of potash (1 : 100) in two minutas ; by carbolic acid (5 : 100) in one hour ; by sulphate of copper (2 :100) in ten days. Löffler found that in the dessicated discharges vitality was preserved for months. Cadéac and Malet found that steriliza-

tion was effected if drying took place very slowly. In putrefying materials virulence lasts for fourteen to twenty-four days, in water for fifteen to twenty days. In the shade in the moist air of the stable it may be preserved for four months.

FIG. 54.

FIG. 53.

Bacillis of glanders (*bacillus mallei*). (Abbott).



Malleus bacilli in a malleus nodule : × 700 (after Plügge).

PATHOLOGICAL ANATOMY OF CHRONIC GLANDERS.—The presence in the tissue of the glanders bacillus and its toxic products usually results in an active proliferation of small round cells (lymphoid) which form nests like miliary tubercles enclosed in a fibrous stroma. These centres of cell development may become confluent and form larger masses, like peas or greater. The centre of the group tends to degenerate, the cells undergoing fatty degeneration and breaking down into a granular débris. There are formed sanious abscesses, ulcers, and cicatrices. In other cases, instead of this softening of the neoplasm, the fibrous stroma becomes denser and an indurated nodule results.

1. On the respiratory mucous membrane two forms occur, and often coexist. After a short period of nasal catarrh in which there is a more active production and granular or purulent degeneration of the mucous corpuscles, the morbid cell proliferation extends into the fibrous sub-

stance of the mucosa and the foci stand out as grains of sand or millet-seeds on the surface. By confluence of two or more they form larger nodules like peas or greater. These are whitish or reddish gray, with a congested peripheral zone and may be isolated or in groups. As they increase the whole mucosa often assumes a dark red or leaden hue, which is, however, less marked as the disease is more chronic. The clusters of lymphoid cells in the centre of the nodule are the palest portion of the lesion, and early break down into a fatty granular débris or pus, which is discharged by bursting, leaving an ulcer of a superficial round or oval or of a deep irregular form. The depth of the ulcer is of a yellowish or lardaceous appearance mixed more or less with red, and the edges are often elevated and overhanging. When two or more ulcers have become confluent the edges are irregular and jagged. The superficial ulcers may heal without leaving any cicatrix, while the deep ones tend to extension laterally or perpendicularly, perforating the mucosa, the cartilages, or even the bones. When these deeper or confluent ulcers cicatrize a distinct stellate or otherwise puckered condition remains. These lesions are common on the septum nasi, the turbinated bones, or are seen after death on the ethmoid cells, on the mucosa lining the antri, or on the Eustachian tubes or pouch. The larynx, too, may be involved, especially the region of the arytenoid cartilages, the epiglottis, or ventricle. In some cases there is diffuse infiltration of a portion or the whole of the nasal mucosa, which is greatly thickened and congested, of a dark red hue, and the seat of superficial ulcers like pinheads or larger, and in certain cases of cicatrices. The cicatrices, however, do not always follow on the healing of ulcers, but result in some instances from a fibroid transformation of the neoplasm.

The bacilli are found between the lymphoid cells, but are comparatively in small numbers in the more chronic cases. Swelling of the submaxillary lymphatic glands is a common feature

2. The lungs are usually the seat of miliarly or larger nodules in chronic glanders. These are gray, translucent, or white, with a dark red zone of investing congestion. If older they may show a dirty gray or yellow necrobiosis in the centre, which may burst and discharge into a bronchus or may undergo calcification. The tissue surrounding such caseated masses has a yellow lardaceous aspect and an irregular, uneven surface very different from the smooth walls of an inspissated abscess or a degenerated hydatid. Secondary nodules appear attached to or adjoining the capsules of these softened masses, especially along the course of the lymphatic vessels, which are inflamed and thickened (corded). The bronchial and mediastinal lymphatic glands are usually implicated.

In place of miliary or fusiform tubercles there may be extensive lobular or lobar pneumonia, starting usually in a perilobular lymphangitis and determining central neoplasms in size from a hazelnut to a mass several inches in diameter, with necrobiotic, or even purulent centres, or of a soft grayish white sarcomatous aspect, or hard and resistant from

the abundance of the fibrous stroma. In their intimate structure these show the same nests of lymphoid cells in a fibrous stroma, spindle shaped cells, and degenerate products as in the nose lesions.

As concomitant lesions in certain cases are found peribronchitis, bronchitis, bronchiectasis, and pleurisy with recent vascular fringes or adhesions.

The pulmonary lesions are primary, from inhalation, in exceptional cases, but usually secondary from the primary foci in the nose, skin, or elsewhere, in the line of the systemic circulation, the bacilli, blood-borne, finding their first opportunity for rest and development in the walls of the pulmonary capillaries. The early implication of the pleura appears to come from a reflux in the pulmonary lymphatics determined by active or deep inspiration.

3. The lymphatic glands on the line of circulation from any existing disease focus are early implicated. Thus the submaxillary glands are always involved on the same side with the affected nasal chamber and the bronchial and the mediastinal glands in cases of pulmonary glanders. There is first an active parenchymatous inflammation with swelling and tenderness, and later a firm induration with diminished vascularity. At first there is the same active proliferation of small round cells, and later an increased fibroid development. Here and there, however, are grayish white nests of cells or yellowish centres of caseation. An hypertrophy of the fibrous covering is a barrier to rupture and discharge of the softened contents, especially in the case of the submaxillary glands.

4. In cutaneous glanders (farcy) the most characteristic features are the formation of rounded nodules (farcy buds) in the derma and in the subcutaneous and intermuscular connective tissue, and the inflammatory thickening (cording) of the lymphatic vessels. The histological elements are the same as in the other glanderous neoplasms. The nodules in the skin, of the average size of a pea, rapidly soften, burst, and form an ulcer discharging a serous or glairy liquid. The nodules in the connective tissue attain from the size of a hen's egg to a large orange or greater, and these, too, rapidly soften and discharge a more or less glairy purulent fluid, and often prove refractory to heal.

5. Other internal organs may be found to be the seat of the specific nodules about in the order following : spleen, liver, kidneys, and testicles. The histological features do not differ from those met in other organs.

Pathological Anatomy of Acute Glanders.—In this the essential microscopic features do not differ from those of the chronic type ; only the disease makes rapid progress, invades successively the different parts of the body, determines active local inflammations and exudations, and early death. If it has commenced in a limb, there may be an inflammatory engorgement of a joint or of the entire member, which for a time hides the nodules and indurated lymphatic vessels. If it starts in the nose, there is excessive swelling of the mucosa and submucosa, with dark

red discoloration and rapidly advancing ulceration. The submaxillary lymphatic glands undergo rapid swelling and may even, exceptionally, rupture and discharge ; and extensive secondary nodules and acute abscesses in the lungs and other internal organs are met with.

One striking feature of glanders is the friability of the bones, especially in chronic cases ; another is the excess of white globules in the blood, the formation of which appears to be stimulated by the irritation of the lymph glands and of the bone marrow.

Symptoms of Acute Glanders.—*In the Horse, Ass and Mule.*—The disease is common in the ass and mule, but infrequent in the horse. After an incubation of three to five days the animal has a rigor, elevated temperature, a profuse muco-purulent discharge from the nose, sometimes mixed with blood or alimentary matters arrested in the pharynx ; if unilateral, this is especially characteristic ; running from the corresponding eye is not uncommon. The margin of the nostril swells, the mucosa is dark red, infiltrated, marked with pea-like yellowish elevations with red areolæ, which in a few days become eroded into increasing ulcers. The discharge is sticky, matting together the hairs and skin of the nostrils. The submaxillary lymphatic glands on the affected side swell, feeling like a bag of peas, tending to adhere by the inflamed (corded) lymphatics to the bone, the skin, or root of the tongue. There may, however, be a uniform swelling filling the whole intermaxillary space. There is early implication (cording) of the cutaneous lymphatics of the cheek and of the body, with nodules, exudations, or arthritis. The condition is rapidly aggravated, and death ensues, usually from suffocation, from the sixth to the fifteenth day.

Symptoms of Chronic Glanders.—*In the Horse.*—The disease may begin with a rigor, but usually the onset appears insidious. There may be muco-purulent discharge from one or (less significant) from both nostrils, becoming sticky and sometimes streaked with blood. The previous occurrence or coincidence of intermittent or continued lameness, arthritis, œdema of a limb, swelling of a testicle, cough, or epistaxis is significant. Still more significant is the nodular, comparatively painless swelling of the submaxillary lymph gland on the same side, feeling like a mass of peas and adherent to adjacent structures. The nasal mucosa is congested, of a dark red on part or all of the septum, and ulcers, superficial or deep and clean, or covered with crusts of a red, black, brown, yellow or green color, are found.

In exceptional cases the submaxillary glands only are apparently diseased, the bacillus having entered the lymph channel through the soft mucous cell or the primary lesions of the mucosa having healed over. In other cases there is only a cough and a grayish uncertain expectoration, the latent lesions being confined to the lungs. In still other cases the lesions are confined to the testicle, the spleen, or some other internal organ, and symptoms may or may not be present.

In chronic cutaneous glanders, with or without œdema of a limb, there may be a nodule on the fetlock, or elsewhere on the line of the lymphatic vessels, with induration of the lymphatic trunks extending from it. The nodules may or may not be multiple, and they may or may not be open and discharging an ichorous or glairy liquid.

Equivocal chronic cases may often be rendered more active and distinctive by a dose of physic, and still more so by poor feeding, over work, impure air, debilitating disease, or any other cause which deteriorates the general health. Acute glanders often follows.

By way of diagnosis, inoculation of the animal itself may be enough. Yet in chronic cases the susceptibility is usually somewhat lessened, and the absence of resulting local lesions is not to be implicitly relied on. A better course is to inoculate a healthy donkey or guinea-pig, which will develop acute glanders in six days.

A prompt and most reliable test is to inject the suspected animal with the sterilized toxic products of the *bacillus mallei* (mallein). This is the exact equivalent of the "tuberculin" test for tuberculosis, and is almost equally trustworthy. The mallein is obtained by making artificial cultures of the *bacillus mallei* in glycerined nutrient liquids, killing the bacillus by heat, filtering it out, and diluting the filtrate with phenic acid solution (2 per cent.) until 1 c.c. is the proper dose for an average horse. First used in 1888 by Helman in Russia with curative intent, it soon came to be trusted as a diagnostic agent because of the local and general reaction which it produced in cases of glanders. The hypodermic injection is made at midnight or very early in the morning, and the temperature is taken four hours later and every hour thereafter up to the sixteenth or later. In cases of glanders the temperature rises gradually to 2° and upward above normal, and falls equally gradually. The rise may last two or three hours only or it may exceed forty-eight hours. A steady rise to 1.5° above normal and gradual fall is ground for suspicion and good ground for a second test later. Atypical reactions in which there is an abrupt rise and fall are not to be trusted as indicating glanders. In addition to the rise of temperature, the glandered horse usually shows weakness, drowsiness, inappetence, staring coat, shivering or tremors, and accelerated pulse and respiration. In the seat of the injection there is active phlegmonous swelling the size of the hand or larger and lasting several days.

Symptoms of Cutaneous Glanders or Farcy.—This may be acute or chronic. In the former case it is ushered in by fever, with rigor, malaise, loss of appetite, high temperature, and suppressed secretions. There may be acute inflammation or swelling of one or more joints of the limbs, or an extensive œdematous engorgement, usually of a limb, in which, or around its margins, may be felt the inflamed and thickened walls of the lymphatics (corded lymphatics), with at intervals nodules the size of a pea or hazelnut. These rapidly undergo softening

and burst, forming a deep ragged ulcer, and discharging a thin glairy, sometimes bloody fluid. If the fever is maintained, there early supervenes a fatal nasal glanders.

The chronic forms generally come on without manifest fever or general disorder. With or without extensive swelling in a joint or limb, the nodules (farcy buds) develop on the line of the corded lymphatics, on or near the fetlock or hock, or on the line of the saphena vein, and tend to burst and discharge, though they may be covered by scabs. Between these nodules the lymphatics are hard and corded. This affection of the lymphatics is characterized by extension from below upward toward the body, whereas in the ordinary acute constitutional lymphangitis in the horse the heat and tenderness are first noticed in the external inguinal glands and extend downward along the line of the saphena vein.

GLANDERS IN MAN.

It was only in 1812 that this disease was recognized in man as being identical with that of the horse. Soon, however, many cases were reported, some acute and others chronic, and all traceable to the same source.

Etiology.—As in other animals, the one essential cause of the disease is inoculation with the *bacillus mallei*. In man it is almost always derived from the horse, and hence the disease is mainly an industrial one, attacking those that come in contact with horses—grooms, coachmen, farmers, veterinarians, horse butchers, horse dealers, soldiers, being especially liable to be infected. Handling the glandered horses with abraded or wounded hands, giving medicine, and scratching the hands on the teeth, receiving on the eye, nose, or other mucous membrane the particles scattered in snorting, drinking from the same trough or bucket with a glandered horse, and using a knife that has been employed on the sores of glanders, are well known occasions of infection. Less common channels are the infected harness, pole, or shafts, the use of handkerchiefs, towels, or clothing after a glandered man, the washing of his clothing (Elliotson), and the manipulation of cultures of the bacillus. In 1889, Dr. Hoffman perished miserably in Vienna from acute glanders contracted from his own artificial cultures. Du Paquin of the University of Missouri also suffered through experimentation, but recovered.

Women do not constitute over five per cent. of the victims, and nearly all are wives of hostlers, grooms, or coachmen or are employed about stables. In 120 cases 1 only was in an infant, and that the child of a coachman who had dressed glandered horses.

The flesh of glandered horses or other animals has often been eaten with impunity, cooking and the gastric secretions both contributing to disinfect it, yet neither of these should be implicitly relied upon, since

dogs, cats, prairie-dogs, lions and polar bears have contracted the disease by eating glandered horses, and abrasions of lips, gums, and tongue are so common that immunity cannot well be hoped for. Moreover, the entrance of the bacillus through the buccal mucosa, the tonsils of pharynx is altogether probable. Persons sleeping in stables occupied by glandered horses, but not handling them, have often suffered, apparently through the virulent discharges dried up on stalls, fodder, or litter, and then distributed as dust to be inhaled. Yet this mode of infection is rare, and horses will often stand for months in stalls near to one occupied by a glandered horse without contracting the disease.

Finally, many men are comparatively insusceptible to glanders, which serves to explain why so few suffer in infected stables, and cases like that of Decroix, who boasted that he repeatedly ate the raw flesh of glandered horses with impunity. Inoculation with the juice of such flesh is usually successful.

Many of the human victims of glanders have been apparently healthy, vigorous men in the prime of life.

Pathological Anatomy.—In man as in animals the morbid process consists essentially in the proliferation, especially in the lymph spaces and glands, of lymphoid and fusiform cells in a fibrous stroma, resulting in coagulation necrosis or suppurative processes, ulceration, or abscess. In man, however, the formation of tumors and the enlargement of the lymphatic glands are less prominent features, and the disease more nearly resembles pyæmia. In the advanced stages pyæmia is a frequent complication. The contents of the glanders abscess, however, is more glairy and bloody, the walls are irregular, grayish or yellowish red, and ulcerating, and the surrounding tissues, especially if in the muscles, are softened and pale. The multiple neoplasms, too, in all stages of progress from the simple congestion, through the solid granulation papule or nodule, to softening or ulceration, together with the occupation of the patient, will serve to correct misapprehension. The skin papules and pustules have often been mistaken for smallpox or rötheln. The advanced specimens contain caseo-purulent contents or a glairy sanguineous fluid covering a coagulation necrosis, and are further identified by the connecting corded lymphatics. The diffuse inflammatory and œdematous lesions may be readily taken for erysipelas, but the characteristic nodules or small abscesses with reddish contents in this focus or in distant parts of the skin and joints serve to distinguish.

In the *nose* the small papules or nodules with grayish or yellowish centres, and the irregular, unhealthy, spreading ulcers, extend to the bone and cartilage and even to the facial muscles and skin, producing the most unsightly swellings and sores. The submaxillary and sublingual glands swell in nodular form, and the intervening lymphatics become corded. Similar formations are found on the mucosa of the pharynx and larynx, the nasal sinuses and palate, the ulcers on the mouth often strongly resembling the syphilitic sore.

When the *lungs* are involved, as they often are, there may be catarrhal bronchitis, peribronchitis, lobular or lobar pneumonia, and pleuritic echymosis and congestion, with more or less numerous miliary or pea-like nodules of a gray, yellowish, or reddish hue, hemorrhagic infarctions and abscesses.

Muscular lesions appear to be most common in the pectoral region and upper limb. The muscle is the seat of a cloudy swelling, a granular degeneration of the fibre, and lymphoid cells multiplying rapidly, forming a nodule which undergoes coagulation necrosis and even suppuration with yellowish, glairy, perhaps bloody contents. The wall has an irregular cloudy yellow or reddish appearance, and the swelling may vary from a pea to a pigeon's egg. Similar formations are found in the subcutaneous connective tissue and lymphatic glands.

The *bone* and *periosteum* are implicated by extension from the superposed soft parts or through the blood, small yellowish nodules appearing on or in them, and the degeneration products detaching the membrane from the underlying bone. This is especially common about the face, the cranium, and the bones of the limbs, and at tendinous insertions.

The *synovial membranes* of affected joints are the seat of congestion, miliary nodules, and abscesses, and the articular cartilage is rough and eroded.

The specific nodules and abscesses are also found in the stomach, liver, spleen, kidneys, testicles, and brain, and an inflammatory form in the brain (myelitis malleosa) is not unknown.

Lesions of the mucosæ are most prominent in the chronic forms, and those of the viscera in the acute.

In all cases the presence of the bacillus in the discharges, the scrapings of the ulcers, or the nodules is a common feature.

Symptoms.—*Acute Glanders.*—*Incubation* in acute cases is from one to three days ; in chronic or subacute forms it may appear to be as many weeks.

In acute cases the initial symptoms are general malaise, weariness, headache, chilliness, and obscure pains in the muscles or joints, especially of the limbs. This may be mistaken for rheumatism or typhoid fever, but this mistake is usually soon dispelled by the supervention of local lesions. Though the infection wound may have healed, it now becomes the seat of itching, formication, pain, redness, swelling, and inflammation, which extend along the lymphatics, as shown by the red and corded lines running out from the cicatrix. Vesicles with reddish contents appear around this ; the wound may burst, discharging a serous or glairy reddish fluid, and the whole arm or face may develop an erysipelatoid swelling. From this the sore may granulate and heal, and recovery ensue, but more commonly the lesions extend and the disease is generalized. The fever increases and becomes constant ; there are anorexia, nausea, vomiting, sweating, constipation followed by diarrhœa,

violent headache, severe pains in the joints and muscles, and great prostration. If there are no local lesions, infection having occurred by the lungs or stomach, it may still be mistaken for typhoid fever, but this will be corrected by the history and later developments.

Soon the skin of the face or body shows red spots which develop into pealike pustules, like smallpox, and these bursting discharge a thick fetid, bloody matter. Or the swellings may be large, rounded, firm, painful, and gradually softer and fluctuating. When bursted or opened they show yellowish red irregular walls enclosing the whitish contents. These may be circumscribed or general over the whole skin, and they may expose muscles, tendons, or bones.

When the nose is affected, which occurs less constantly in man than in the horse, there is a thin, sticky, catarrhal flux, with occasionally a brownish, greenish, or reddish discoloration, and fœtor. Nodules and ulcers with irregular borders and lardaceous yellowish base can usually be seen on the mucosa or on the skin adjoining the nostril. The nose or whole face may swell, become tense and ulcerate, and the lymphatics leading to the lower jaw become hard and corded. Catarrahal discharge and ulceration may appear in eye and mouth, the breath becomes intolerably fetid, and swallowing and even breathing difficult from implication of pharynx and larynx. The breathing is snuffling or oral, the nose being closed by swelling, scabs, and discharge, and the nostrils agglutinated together.

The implication of internal organs may be shown by cough, pain in the chest, bronchi, and other morbid chest sounds, nausea, vomiting, fetid diarrhœa, jaundice, abdominal tenderness, albuminuria, and the presence of leucin, tyrosin, and other imperfectly oxidized products in the urine.

The pulse becomes rapid, small, thready, or imperceptible ; the temperature may reach 106° F., and the mind may be clouded or delirious. Death ensues from collapse following stupor and coma, or from dyspnœa.

Chronic Glanders.—The constitutional disorder is usually present from the first, but is much less marked. Ulceration appears in the infection wound, or swellings and corded lymphatics in its vicinity ; also swelling of the lymphatic glands. These are usually on the bare parts of the skin, the face, and upper extremity. The ulcers are indolent, and, though healing in part, will give rise to nodules and abscesses around them, which burst, discharging a sanious pus, and are tardy to heal. Abscesses may appear at distant points or gradually over the body with erysipelatoid inflammation, especially of the face, and arthritis. Thus the acute and fatal form supervenes.

When the nose is affected the lesions do not differ from those seen in the acute form, but they are more circumscribed and indolent. The nodules, ulcers, and sticky, foul discharge agglutinating the nostrils are no less characteristic. This may not appear in more than one half the

cases, and often not for months after infection. The mouth and throat become involved, with fetor, salivation, difficult deglutition and breathing, and the implication of the lungs is shown by cough, dyspnœa, and morbid chest sounds.

There is a variable but remittent fever, and the patient becomes pallid, emaciated, and debilitated, and the disease merges into the fatal acute type.

When the symptoms improve in mild chronic cases recovery may be hoped for. The fever decreases, the pulse improves, the swellings subside, the ulcers and abscesses granulate and heal, and appetite and digestion improve. Recovery is slow, and from four months to as many years may be required to effect it. With serious lesions of the lungs or other internal organs difficult breathing, general debility, and weakness are persistent.

PROPHYLAXIS.—The prevention of glanders in man can only be obtained by its extinction in the equine family. But this will never be accomplished by present methods. Laws forbid the keeping of glandered horses, but they are largely a dead letter because there is no proper machinery for their execution. The application of the mallein test to all glandered studs, the destruction of all glandered horses, the disinfection of carcasses, stables, harness, vehicles, utensils, fodder, litter, manure, would soon make the disease extinct. Until this can be effected all who handle horses should be instructed in the danger, and enjoined never to touch a suspected animal or anything belonging to him with any sore on the hands ; to wash hands and face in a solution of carbolic acid (1:200) after handling a glandered animal or anything belonging to him or with which he has been in contact ; to burn the manure of the affected animal ; to destroy or disinfect the stall, harness and utensils ; to boil all clothing that has been on the horse or his attendants, and generally to guard against any possible channel of contagion.

TREATMENT.—*In Animals.*—In view of the danger to man some countries legally prohibit the treatment of glanders in animals. While a sound economy and an enlightened sanitation demand the purchase and killing of all glandered horses at public expense, yet it must be allowed that in the dry atmosphere of the Northern States, and especially in the Rocky Mountain region, glanders is by no means so fatal as in Europe. When a state has no systematic method of extinction with indemnities and penalties, a horse-owner may claim a right to treat his chronic cases, but he can never have a right to expose them on the highway or in any public place. They should never be left in the same stable with other horses. The unbroken nodules on the skin may be treated with iodized phenol or they may be injected with carbolic-acid solution (1:200). The open sores may be injected or washed with this same or with a solution of permanganate of potash (1:60). Active caustics are sometimes used, such as iodized phenol and strong solutions

of sulphate of copper or of iron, or chloride of zinc of mercury. Iodoform makes an excellent application. For the nose weaker solutions may be used, as mercuric chloride (1 : 5000). The animal should be kept, if possible, in the open air, on a generous diet and with moderate exercise. As tonics quinine, sulphate of copper, biniodide of copper, nitrate of baryta, arsenic, and strychnine have been given with success. Arsenate of strychnine 2 grains daily and bisulphite of soda ½ ounce thrice a day may be specially commended

In Man.—In the early stages the inoculation wound should be cauterized by a white hot iron or electric cautery or by undiluted mineral acid. Ulcers and open sores may be similarly treated, or they may be washed with carbolic acid (1 : 200), permanganate of potash (1 : 30), chlorinated water, or mercuric chloride (1 : 2000). Erysipelatoid swellings may be freely injected with chlorinated water or permanganate of potash solution, and covered with a compress soaked in the same, evaporation being prevented by oiled silk or gutta-percha cloth. The nose should be treated by insufflations of iodoform, by creosote water, or by carbolic acid solution. Finally the general health must be most carefully attended to, pure air, nourishing food, stimulants, beef tea, wines, etc., the regulation of all the natural functions, and finally tonics, such as quinine, iron, arsenate of strychnine, are demanded. Fever and other distressing symptoms must be met according to indications, though febrile cases are usually fatal. As an accessory the internal use of antiseptics, such as sulphites and iodides, is to be commended.

ANTHRAX.

Pp. 753-762.

DEFINITION.—Anthrax is an acute infectious disease occurring in herbivora (cattle, sheep, goats, horses, asses, rabbits, buffalo, deer, elk, elephants, camels), and omnivora (swine), and communicable to nearly all warm-blooded animals, including man. It is characterized by the presence in the diseased tissues or liquids of the *bacillus anthracis*, by enlarged spleen, by delayed oxidation of the blood, by destruction of the red blood globules, by capillary embolism, by extravasations or exudations and by local gangrene.

ETIOLOGY.—The one essential cause of the disease is the entrance into the system of the bacillus anthracis or its spores, yet many accessory conditions are so important that their removal will go far toward the local extinction of the malady.

Soils that preserve the bacillus and spore in a virulent state are dense clays, wet soils, undrained deltas, bottomlands and basins, drying ponds and lakes, and soil rich in decomposing organic matter and evolving ammonia or otherwise neutral or slightly alkaline from the presence of lime. In other words, it is such soils as contain food for the bacilli and admit only a limited amount of oxygen. When such soils are thoroughly drained and rendered porous and aërated, the bacillus perishes or loses its pathogenic property, as it does in sandy or gravelly soils with natural drainage. For the same reason thorough cultivation and the frequent exposure of an infected soil to the air tends to rob it of its virulence. On the other hand, the bacillus retains its potency long in the mud of swamps, ponds, lakes, and wells, and will infect through the drinking water.

Season is a potent cause, the dry heats of summer and autumn evaporating the water and leaving the dust charged with the bacillus to blow on the vegetation and thus reach the victim. Sometimes the hard baked surface soil imprisons the germ, which escapes after this has been broken up by rain. In a wet season, too, the grasses are torn up and the stock are infected by the bacilli in the earth adherent to the roots. For the same reason turnips, beets, and other roots may convey the disease through the infected soil adhering to them when eaten. Sometimes a heavy rainfall will cause widespread infection, the bacilli being washed away into streams, ponds, and other drinking places.

The *graves* of anthrax victims are always extremely dangerous and may become increasingly so when the soil water rises to the surface bearing the bacilli. *Earth-worms* also bring the germs to the surface and deposit them in the little worm casts, in which they have been demonstrated by inoculation and otherwise. Rats and mice may also exhume the virus by burrowing into the graves.

Flies convey the germ from animal or diseased products or carcass to animals, especially, the house flies, horse flies, blow flies, etc., which suck the blood and infecting liquids and carry the germ on feet or proboscis or in the intestines and deposit it on other animals, and especially on sores.

Ground bones have been charged with infecting soils, while harness, implements, hay, straw, and other fodder will convey the disease to stock. To feed hay from infected meadows is not so dangerous as to pasture them when damp, yet the dust blown on such hay will infect animals in midwinter with a temperature at zero.

Infection direct from the soil is most frequent in late summer and autumn, producing enzoötic and epizoötic outbreaks, while winter cases may seem sporadic, yet even these may be numerous and the infection may pass through unexpected channels. Thus cats, dogs, and horses perish by licking the blood of a defunct ox, and healthy animals suffer from following the sick in feeding from the same manger or rack. One of the most fruitful causes of anthrax is leaving the bodies of the victims in the pastures unburied or only partially buried. Under access of air the bacillus forms spores which in a suitable soil or dry condition may be preserved indefinitely. Dogs, too, and wild animals devour the carcass, and even if they escape infection they carry it on their jaws and legs and sometimes directly inoculate it by a bite.

FIG. 55.

Threads of *bacillus anthracis* containing spores : × about 1200 diameter. (Abbott.)

Certain conditions operate on the exposed animal to make it more receptive. A hot sun producing a febrile condition and aggravated by privation of water, cold rain or snowstorms, lying on the wet or frozen earth, eating frosted vegetables, or, indeed, anything that causes chill or temporarily lowers the vitality, will act in this way. Both chicken and frog are normally insusceptible, but the chicken succumbs if its body is

chilled, and the frog if its temperature is raised to that of a warm-blooded animal. Plethora predisposes, and thus the victims are often animals that have been thriving most rapidly. Young animals, too, and those fresh from a healthy locality are especially susceptible, never having been inured to the toxic products of the bacillus.

Bacillus Anthracis.—The bacillus anthracis was demonstrated in anthrax fluids by Pollender and Brauel in 1849, but, failing to recognize the presence and importance of the spore in infecting liquids from which the bacillus was absent, they concluded that this organism was not the etiological factor. Davaine, in 1863, showed that it was the real cause of anthrax.

As propagated in the living animal, the bacillus is a rod 5 to 20 μ long and 1 to 1.25 μ broad. It stains well with aniline colors and also by Gram's method. It is aërobic, yet grows at the bottom of a stab culture, and is sterilized by exposure for six or eight hours, in thin layers, to full sunshine in free air. It is non-motile, unlike the bacillus subtilus and other saprophytes which strongly resemble it morphologically. It

FIG. 56.

Bacillus anthracis: plaited and twisted threads seen in fresh growing cultures; × about 400 diameters. (Abbott).

grows readily in ordinary culture media that have a slightly alkaline or even a neutral reaction, forming long filaments which in free air produce endogenous spores. These spores never form in the living tissues or fluids, where air is deficient, but they are produced after death on the surface of the carcass, on the hair, wool, fur, bristles, hides, or on spilt blood or infecting discharges. In slightly acid media and in such as contain carbolic acid (1 : 1000) spores will not form. The dry spores can be preserved for years without losing any of their virulence. They are only destroyed in dry air by three hours' exposure to a temperature of 140° C., but in water they perish in ten minutes at a temperature of 100° C. The bacilli are killed in ten minutes at 54° C., and in two hours in solutions of carbolic acid (1 : 300), mercuric chloride (1 : 10,000), or hydrochloric acid (1 : 1100).

PROPHYLAXIS.—Anthrax being an enzoötic disease primarily dependent on the condition of the soil, thorough drainage, and to a less extent, culture, are means of preventing the affection. Where infected lands cannot be drained they should not be used for pasturage, but devoted rather to the raising of crops that will be cooked before they

FIG. 57.

Anthrax bacilli in the blood of a guinea-pig thirty-six hours after inoculation. (Charcot).

are consumed. The bodies and stalls of the sick should be washed with an acid solution to prevent the sporulation of the bacillus. Carcasses should be left unopened, and the whole surface and air passages treated with hydrochloric acid or chloride of lime. Sporulation does not take place in the interior of the carcass. The carcass should be burned, disintegrated in a mineral acid, or, if buried, it should be conveyed in a closed vehicle from which nothing can drop on the way, and the grave should be in a fenced place distant from wells, streams, and pastures, and in an open, porous sandy or gravelly soil, in which the infection will soon disappear. The manure should be burned or saturated with a mineral acid, and not applied to pastures or meadows. Any excretion, blood, or other product of the diseased or dead animal should be saturated with a strong mineral acid or with carbolic acid. The stall where the diseased animal has been should be cleansed and thoroughly washed with carbolic-acid solution (1 : 300) or mercuric-chloride solution (1:500). The sick animals must be debarred from common drinking or feeding troughs, and from buckets used for other animals, and all dogs, chickens,

pigeons, and other animals must be carefully excluded from their stalls. It need not be added that the sale of their milk, flesh, skins, wool, hair, or bristles is to be severely condemned.

In districts which cannot be drained and rendered wholesome many of the young become inured to the poison by receiving the toxic matters in small, non-fatal doses in their milk, and later in their food and water, and when attacked the disease is mild and they recover. This can be availed of artificially in various ways. Thus cattle may be safely inoculated with the bacillus which has passed several times through guinea-pigs or mice. Pasteur cultivated the bacillus in bouillon at 42° C., thus preventing sporulation, but then left it twenty days without reseeding on a new flask, and found it had become non-fatal to the larger animals. It required a longer rest to make it harmless to the small ones. Chauveau and Touissant heated the cultures to 55° C. for one hour, and thus rendered them non-fatal to the larger animals. The last two methods have been employed for inoculation of many thousands of animals in anthrax districts with the effect of giving them immunity. Among the drawbacks to the method is the risk of having the germ assume a greater virulence by passing through a young and susceptible subject or one with excess of lactic acid in its system as the result of severe muscular exertion, and the danger of infecting through the inoculated animals dense soils which had not previously harbored the bacillus. It should be reserved, therefore, for cattle on land already infected or so porous that infection cannot survive in it.

A safer method was foreshadowed by Touissant in 1880. He filtered anthrax fluids and injected the germ-free liquid with the effect of conferring immunity. Having assured myself of its efficacy in other self-limiting diseases, I in 1884 applied this to anthrax. Heating the anthrax blood or serum to 158° F. for one hour and injecting one drachm per head on each of two successive days, I have never failed to arrest the disease in a herd of cattle. Chamberlain, Roux, and Hankin have lately had equal success with toxic products of the cultures. Care must of course be taken that the blood has not been allowed to sporulate before the heating.

A new field of therapeutics of this disease in animals is of interest, from the hope that some such method may yet prove successful in man. Bouchard, Charrin, and Guignard find that rabbits with a fatal dose of anthrax are preserved by one or two injections of culture of *bacillus pyocyaneous*. Emmerich, Pawlowsky, and Friedenreich have found the same good results from cultures of *micrococcus prodigiosus*, *staphylococcus pyogenes aureus*, or *streptococcus erysipelatus*, and Woodhead and Wood find that the sterilized cultures of these are equally successful.

ANTHRAX IN MAN; MALIGNANT PUSTULE; INTERNAL ANTHRAX.

ETIOLOGY.—Anthrax in man is almost invariably the result of infection from animals, yet there is no reason why man should not be infected directly from soil or water containing the bacillus or spore. The common source, however, makes this essentially an industrial disease, which attacks employés at rendering works, butchers, tanners, workers in leather, rags, wool, hair, bristles, hides, bones, hoofs, furs, felting works, glue factories, shepherds, cattle men, horsemen, veterinarians, and which appears largely on the uncovered portions of the body (face, hands, neck, arms). The local anthrax is especially conveyed to man by bloodsucking flies (house flies, bluebottles, mosquitoes), or when more direct, it is from hides and other animal products derived from anthrax regions (Russia, Armenia, China, South America). Yet even in our home products there are many infecting articles, so that workers in these products are often exposed. As derived from flesh the bacillus perishes in the acid secretion of a healthy stomach, so that it is only the spores that can escape and determine intestinal anthrax. If introduced by inhalation, as from dried hides, hair, wool, bristles, and rags, it usually develops first in the bronchia and extends later into the lung tissue and blood. An occasional infection takes place from man to man through lancing the swellings, dressing the sores, or less directly through washing the clothes.

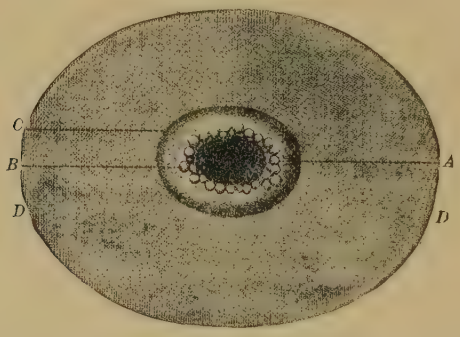
The predisposition to anthrax appears to be less in man than in the herbivora, yet a direct inoculation on one who has not already suffered is usually infecting. Following its animal origin, the greater number of cases occur in the summer and autumn. In man, as in animals, the presence of a small quantity of lactic acid greatly enhances the virulence of the bacillus, hence the predisposition is enhanced by severe muscular exertion with the increased production of sarcolactic acid.

PATHOLOGICAL ANATOMY.—This is essentially the same as in the animal. The bacillus induces a local non-suppurative inflammation, with rapid accumulation of leucocytes, blocking of the capillaries with dark non-aërated, distorted blood globules and bacilli, more or less abundant exudation of a gelatinous and bloody fluid, and the supervention of coagulation necrosis. There is the same enlargement of the spleen, congestion of the liver, venous condition of the blood, rise of temperature and pulse, the same capillary embolism and minute extravasations in all parts of the body—the same cyanosis, oppressed breathing, coma, and death. There is the same black, tarry, comparatively incoagulable blood and an unusual tendency to hypostatic discoloration. The cutaneous and pulmonary forms demand a special notice.

In *malignant carbuncle* (*pustule*) there is the central congested papule with its blocked capillaries giving a peculiar dark red shade to the

lesion, or later there is a mass of necrotic tissue of the same dark color and covered by a black eschar. Around this are more recent papules and vesicles with blood-stained contents and a firm base of embollic capillaries, multiplying leucocytes, and blood extravsations. Around this is an œdematous and phlegmonous infiltration of the skin and subjacent structures. On section the necrotic or phlegmonous nodule is seen to extend deeply into the subcutaneous connective tissue with softer blood-stained extensions in different directions. Later there are the concurrent lesions of general infection.

FIG. 59.



Malignant pustule: *A*, Central eschar; *B*, vesicular areola; *C*, peripheral infiltration; *D*, œdematous skin. (from Charcot).

In *anthrax œdema* there is a diffuse phlegmonous inflammation without any central nodule. Capillary embolisms and minute blood extravasation are present, but are overshadowed by the abundant œdematous swelling in the loose connective tissue. The rapidity with which it spreads and becomes fatally generalized renders the occurrence of open sores a rare condition. It has been seen especially in the eylids, the neck, and the forearm, where the connective tissue is abundant and loose and poorly supplied with bloodvessels.

In *pulmonary anthrax* there is intense congestion of the lungs with numerous minute blood extravasations into the parenchyma, bronchi, and alveoli, with similar phlegmonous enlargement and blood-staining of the bronchial, mediastinal and inferior cervical glands. By his experiments in causing guinea-pigs to inhale the spores in steam, Buchner showed that the bacillus first propagated itself in the smaller bronchi and air cells, and made its way through the epithelial cells by process of growth before the lung tissue and blood became infected. Blood-stained exudations into the pleura and pericardium are usually present. Pulmonary anthrax becomes rapidly generalized; hence all the concurrent lesions of that form are met with. As in all other forms of the disease, the presence of the bacillus in the blocked vessels and exudate is char-

acteristic. In the tissues the bacilli are rarely uniformly diffused, but aggregated in groups or felted masses. Apart from the primary seat of infection, the lymphatic glands usually contain them in the greatest numbers.

SYMPTOMS.—*Malignant carbuncle* (*pustule*).—Usually a few days after exposure to the infecting material the patient notices a burning and itching, and soon there appears a slight, hard, papular elevation like a fleabite, but with a very dark red centre, on which a small vesicle later appears. In twenty-four or forty-eight hours this has increased to half an inch in diameter, is firm, tender, and painful, and the centre which has burst or been opened by scratching is gangrenous, brownish red or greenish black. This is surrounded by a swollen red or violet areola, shading off into blue or yellow, and, if the disease continues to extend, by a circle of new vesicles from a hempseed to a pea in size, which pass through the same transformations. An œdematous engorgement extends from the centre, sometimes limited and sometimes including the entire arm or head and neck, and there is distinct enlargement and tenderness of the adjacent lymphatic glands. There is always more or less constitutional disturbance, headache, pains in the back and limbs, weariness, nausea, and, in bad or neglected cases, generalized anthrax supervenes.

In milder cases the slough is separated in connection with the process of suppuration, the sore granulates, and the surrounding swelling and general symptoms subside.

Apart from the virulence of the infecting material, certain conditions have much influence in determining the result. The dense and vascular tissues of the derma favor an active inflammation and a liberal production of leucocytes, which contest the field with the bacilli hemmed in by the dense inflamed tissue around. Then the introduction of the pus microbes further antagonizes the bacillus anthracis, and if free suppuration is established a favorable tissue may be expected. On the other hand, if the sore remains dry and the infiltration extends rapidly in the connective tissue and lymphatic glands an unfavorable result may be dreaded. Yet for the first forty-eight or sixty hours the disease is in the main local, and vigorous local treatment may be expected to succeed.

Anthrax Œdema.—Appearing in loose and comparatively non-vascular connective tissue, as in the eyelids, neck, or forearm, this shows the phlegmonous œdema, without at first much increase in the vascularity of the skin, and without the papule, vesicle, and sloughing nodule. Not being circumscribed by firm inflamed walls and rapidly multiplying leucocytes, it extends with great rapidity and tends to early general infection. In the milder cases, however, recovery may ensue, and in some instances, vesicles and gangrenous sores may appear.

Anthracœmia.—As in animals, internal anthrax may go on to an early death without any distinct symptoms of localization. There is a sense of

depression and weariness, restlessness, insomnia, pains in back and limbs, and even cold perspiration. With or without these premonitory symptoms there follow chilliness or rigor, nausea, vomiting, headache, great prostration, profound mental depression, and anxiety, coldness or numbness of the limbs, difficult breathing, stupor, coma, and death in forty-eight hours or in three days. A dusky or cyanotic condition of the skin and mucous membranes, and the appearance of blood in the urine or stools or in the nose or eyes, may further identify the affection.

Intestinal Anthrax.—After eating diseased flesh, sometimes as early as after eight hours and at other times after twenty-four or forty-eight, the patient is affected with chilliness or rigor, abdominal pain, nausea, vomiting, bloody diarrhœa, headache, extreme prostration and weakness, restlessness, difficult breathing, and, in from one to three days, stupor, coma, cyanosis, dyspnœa, and death. Bleeding from the pharynx or mouth is further characteristic. Glandular swelling of the neck with infiltration of the connective tissue may also be present. The pulse is small and rapid, and the temperature only slightly elevated. External localization may accompany this, and in some cases in which the abdominal symptoms have been comparatively slight and prolonged an extensive external anthrax may later become the most prominent feature.

Pulmonary Anthrax (*Wool-sorter's Disease*).—In this the chest symptoms predominate. There is usually the same general sense of malaise, depression, weakness, chilliness, with headache, nausea and perhaps vomiting. On auscultation there may be rhonchi and patches of crepitation. There is an oppression of the breathing altogether disproportionate to the appreciable lesions. There is also marked flushing of the face amounting perhaps to cyanosis. Cough is present but not violent. Sore throat and swelling of the cervical glands may be present. The prostration becomes extreme, stupor or delirium supervenes, with dyspnœa, cyanosis, collapse, and death in from twelve hours to two or even five days. These cases are generally fatal, and though they may remit, they as constantly relapse. The occupation of the patient, the rapidity of the onset, the early extreme prostration and exhaustion, the stupor, delirium, cyanosis and collapse serve to identify the disease. The swelling of the throat and neck, and the bleeding from the pharynx and kidneys may also serve for diagnosis.

Diagnosis.—This must always be made in case of difficulty by a microscopic determination of the bacillus with its characteristic large size, immobility, and square ends, and, if need be, by inoculation of a rabbit or mouse, which in anthrax will die with the characteristic symptoms in two days. The bacillus may be sought in the vesicle, the sloughing indurated centre, the œdematous swelling, or the bloody expectoration, urine, or stool.

Prophylaxis.—In addition to the radical measures laid down for animals, the following points are important: Persons with sores on the

hands, hangnails, etc., should on no account handle animals or men suffering from anthrax or their products. If this has been done inadvertently, the sores should at once be cauterized with silver nitrate and dressed with carbolic acid (1 : 300). Workers in tanneries should avoid letting the hides come in contact with face, neck, or shoulder, and should wash the hands frequently in a solution of mercuric chloride or carbolic acid when handling suspected specimens. Wools, hairs, etc., from anthrax localities should be laid loosely in a room with steam until damp throughout, and then subjected to strong fumes of burning sulphur for twelve hours. Those who handle the articles prior to disinfection should wear respirators of cotton wool which may be disinfected by heat. The sale of anthrax hides, wool, etc., should be interdicted unless they have undergone a thorough disinfection under official supervision. Marketing the flesh or dairy products of even mild cases of anthrax should be forbidden by law, and guarded against by the strictest inspection in stock yards, in municipal abattoirs, etc. A diffusion of information as to the nature and danger of anthrax is a most essential precaution, and in anthrax districts and in factories likely to use anthrax products antiseptics such as carbolic acid solutions should be always at hand.

TREATMENT.—The most essential thing in external anthrax is the thorough destruction of the local affection. In the initial stage with only the dark red spot or papule the complete destruction of this with a red-hot needle is effective. In more advanced cases with a hard nodule and œdema the surface may be sponged with a 10 per cent. solution of carbolic acid, and the hard part excised with as much of the surrounding œdema as can be safely reached. The wound may then be filled with surgical cotton soaked in the same solution and the skin brushed over with the same lotion. In the more advanced cases and in anthrax œdema so extensive as to forbid complete excision the whole affected area must be filled with the carbolic injection by means of a hypodermic syringe passed into all parts in succession and emptied as it is being withdrawn. The surface may be covered with cloths wet in mercuric chloride solution (1 : 500) and by an ice bag. Enlarged lymphatic glands may be excised and the wound treated with the carbolic acid lotion. If the edges of a wound continue to rise, a thorough cauterization should be repeated.

In internal or general infection resort is had to quinine 10 grains and carbolic acid 7 grains four times a day ; to large and frequent doses of tincture of muriate of iron, 20 drops every four hours ; and to stimulants. In the earliest stages attention should be directed toward local destruction of the bacillus. If anthrax flesh has been eaten, an active emetic may be followed by carbolic acid and perhaps pyoktanin ; in cases of inhaled spores the breathing of carbolic acid and fumes of burning sulphur will be especially indicated.

Finally, a resort may be had to one or other of the bacteria that have been so successful experimentally in the lower animals. A pure culture of the pneumococcus of Friedländer, the bacillus pyocyaneus, or of the staphylococcus pyogenes aureus, thoroughly sterilized by heat and injected subcutaneously (and in intestinal anthrax swallowed), may assist materially in arresting the disease. Similar injections might be made into the peritoneum in intestinal anthrax, into the trachea and pleuræ in the pulmonary form, and into the œdematous swelling in the external.

RABIES.

Pp. 763-773.

SYNONYMS.—Hydrophobia ; Canine madness.

DEFINITION.—Rabies is an acute febrile disease, propagated by inoculation only, and characterized by a prolonged incubation, followed by an access of fever and of nervous disorders of a characteristic type. The habits become unnatural and depraved, the temper irritable and uncontrollable, reflex excitability extremely exaggerated, visual illusions and hallucinations are developed, and spasms and paralyses of the muscles set in. If neglected it is almost invariably fatal.

Animals Susceptible.—The disease is most common in the canine races (dogs, wolves, foxes, jackals, hyenas, etc.,) and in felines (cats, lions), partly because of innate susceptibility, and largely because of their tendency to bite and get bitten and inoculated. Warm-blooded animals, however, appear to be universally susceptible or nearly so—cattle, sheep, goats, deer, horses, asses, mules, badgers, apes, rabbits, rats, mice, chickens, pigeons, etc., furnishing victims. Skunks not only suffer, but from their fearlessness and disposition to bite on the sly are very effective as propagators of the infection. Man suffers from the bites of mad dogs, cats, and, less frequently, from wolves and skunks. All genera are not equally susceptible, and some, like apes, hens, and sheep, reduce the potency of the virus passed through them.

ETIOLOGY.—There is only one cause—namely, inoculation from an animal suffering from the disease It may be assumed that the virulent principle is an organized germ, but so far all attempts to isolate and cultivate it in a pure culture have manifestly failed. Pasteur and Fol found in the nerve centers of rabid dogs micrococci 0.02μ in diameter, and often joined in pairs. Rivolta found streptococci of four or five elements, and Babes found a coccus 0.5μ to 0.8μ, which he cultivated in blood serum or gelatinized bouillon at 37° C., and inoculated in the brain successfully in some cases, but mostly without success. After the second or third generation it proved non-pathogenic. Dowdswell, Mottet, and Protopopoff have also investigated the subject, but, though the last two claim to have produced typical rabies by their cultures, the microbe cannot yet be certainly identified.

All indications, however, show that the *materies morbi* is a microbe. The inoculation of the smallest particle of virulent saliva or brain

matter produces a fatal general disorder in which the infection is multiplied and pervades all organs and liquids of the body. The long period of incubation is incompatible with poisoning by a chemical agent, which would operate promptly if at all, and be eliminated long before the rabies sets in. Rabies agrees with all other germ diseases in developing only after inoculation, in that one attack usually protects against a second, and that it never appears for the first time in a country from which mad dogs are excluded (Australia, Tasmania, New Zealand, St. Helena, South Africa, West Africa, the Hebrides, the Azores), whilst it does continue and become permanent in localties previously free, but into which infected dogs have been brought (Buenos Ayres, Malta, Hong-Kong).

In spite of popular prejudice, abuse, neglect, privation, and season have no effect in generating rabies, though they may increase susceptibility. It is probably hopeless to eradicate the dread of the dog star and the dog days, but statistics show a steady rise of cases of rabies in early spring, before the advent of the hot summer months. Thus, Bouley had 755 cases in December, January, and February ; 857 in March, April and May ; 788 in June, July, and August ; and 696 in September, October, and November. The real explanation of the extra prevalence in spring and early summer is found in the fact that the bitches rut in spring, and the numerous candidates for their favors bite each other fatally. This is aggravated by the fact that the generative instinct is stimulated in the early stages of rabies, so that any developing cases are likely to follow a rutting bitch. This further explains the predominance of rabies in males (1746 males to 244 females), the irritable rabid dog antagonizing his male competitors and respecting the female object of their common desire. The suppression of the generative desire, invoked as causing *rabies de novo*, only develops it in infected countries and in animals already bearing the germ, never in countries where rabies did not previously exist. The excitement will hasten the eruption in the inoculated animal, but will never develop the disease *de novo*. The bite of the dog in a violent passion or under any other form of excitement is not rabific unless he has himself been bitten and is mad. The same is true of the skunk. Its teeth may be infected from eating carrion and produce septicæmia, but, unless in limited districts where skunks have been infected with rabies, the bite will not prove rabific.

Broad generalizations show the impossibility of spontaneous cases of rabies. The absence of the disease in islands in the Elbe while rabies was epizoötic on both banks ; its absence for centuries from the Hebrides and Malta, each with its special breed of dogs, though constantly present on the mainland ; and its prompt disappearance from Berlin, Eldena, and other cities when all dogs were strictly muzzled,—sufficiently prove the absence of any cause save infection. What never occurred in the past need not to be looked for in future. Cases in

which infection is denied because the dog was shut up will be explained by a more thorough investigation. Rabid dogs will leap high fences to reach a supposed enemy, and rabid rats and other vermin enter through small holes.

Rabies like most microbian diseases is at first confined to the region of the bite, and the tissues there alone are infecting. When fully developed the infection is resident in the blood and all vascular tissues, yet the usual source of infection is through the bronchial mucus and the saliva, both of which are especially virulent and are naturally implanted by the teeth. This virulence is not confined to carnivora, but has been experimentally demonstrated in omnivora and herbivora as well, and may be inferred for birds. Various cases of infection from man to man are on record. Drying of the saliva or blood apart from heat or putrefaction does not destroy its virulence, and knives fouled on rabid animals have been used for successful inoculation months and years later.

Among other methods of infection besides the bite may be named the licking of a sore by a dog in the early stages of rabies and the occupation of kennels or stalls that have previously harbored rabid animals. Rabies has been known to attack a second pack of hounds after the first pack had been killed out because of the disease, and the only way to prevent this is by a thorough disinfection or destruction of the kennels. The mangers and feeding dishes charged with expectoration and saliva are pre-eminently dangerous. In one case a man was infected by using his teeth to untie a knot in a rope that had been used to tie a mad dog.

Infection in man has been caused by a bite from a dog that had been previously fighting a rabid dog, and again from the scratch of a cat that had been licking its claws. Again, as recoveries are not unknown (though very rare), and as dogs may be immunized by inoculation, it follows that a dog may communicate the disease without itself showing any symptom. In some cases of incipient rabies in dogs the saliva has been virulent before any outward symptoms were shown; hence all dogs, however sound in appearance, are objects of suspicion in an infected district.

Bollinger suggests the possibility of infection by fleas and lice which have lived on the rabid dog and sucked its blood.

No case of infection through milk or semen has been proved. The percentage of those bitten by rabid animals that contract rabies is greater in animals than in man, because the bites in man are mainly made through clothing, which cleans the teeth of the virus before they reach the skin. Even in man this distinction holds, since the bites of wolves and hounds, that fly at the face and throat, are far more fatal than those of dogs on the clothed parts of the body. Bites on the face, too, as being nearer to the brain, the seat of the election of the affection, produce the disease earlier and with greater certainty. Bouley found that

90 per cent. suffered after bites on the face, 63 per cent. after bites on the hands, 24 per cent. after bites on the arms, 7 per cent. after bites on the legs, and 63 per cent. after (mostly multiple) bites on the body. Of dogs 49.7 per cent. suffered, of cattle 61.6 per cent., and of sheep 42 per cent. The susceptibility of sheep is known to be slight, and the teeth are more likely to be cleansed on their wool. Much, however, depends on the stage of the disease and the abundance and virulence of the virus in the saliva as well as upon the susceptibility of the subject. Some are insusceptible either naturally or by reason of their having been previously subjected to the products of the germ, yet under a full virulent dose nearly all succumb.

PATHOLOGICAL ANATOMY.—The macroscopic lesions of rabies are somewhat obscure. Taken, however, with the microscopic appearances and the symptoms shown in life, identification of the disease is not usually difficult.

In *animals* there is emaciation, mucus about the eyes, mouth, nostril, and prepuce, staring coat, venous congestion, and livid mucosæ. The tongue has a dirty brown fur, the pharynx is often red and congested ; in cattle I have seen the vocal chords ulcerated. In the dog foreign bodies such as straws, hairs, pieces of wood or clothing, may be found in the mouth or pharynx. The pharyngeal lymphatic glands are usually dark from blood engorgement and extravasation. The salivary glands are grayish red and collections of lymphoid cells may be found around their follicles. The gullet contains grayish tenacious mucus and sometimes traces of foreign bodies. The stomach is congested and contracted. In the dog it contains no food, but a mixture of foreign bodies and indigestible substances which are highly characteristic of the disease—hair, straw, wood, coal, bits of leather, cloth, dirt, grass, and stones, bespeaking the depraved appetite during life. The mucosa is brownish red or deeply congested in parts, with petechiæ and even ulcers. A yellow viscid mucus covers it at points. The small and sometimes the large intestine, with little or no ingesta, may contain masses of foreign bodies and bile-stained mucus. The liver is congested with a black tarry blood, and its cells are the seat of granular degeneration. The mediastinal glands are congested, the kidneys hyperæmic, and the bladder contracted and empty or holding only a little yellow, turbid, albuminous urine. The bronchia may be slightly congested and occasionally enclose foreign bodies, and the lungs are the seat of venous congestion, but of no other marked change.

On removal of the calvarium the cerebral meninges are found hyperæmic, the sinuses gorged with dark blood, with minute extravasations and thickening of the membranes due to interstitial fibrinous exudate and cell production. The epithelium of the central cerebro-spinal canal may be increased, and at points broken down and replaced by blood or granular or hyaline masses. In the gray matter around and on the

floor of the canal may be found minute hemorrhages, which under the microscope are found to correspond to thrombosis of a capillary with leucocytes or a hyaline pigmented mass. Such points found in the gray matter of the spinal cord and bulb and in connection with the motor centres are characterized by the accumulation of lymphoid cells in all the coats of the vessels and in the perivascular lymph space, along with granular and hyaline matter. Babes and Mikailescu further describe changes in the nerve cells, with cloudiness of the protoplasm, with vacuoles, and in the nucleus karyokinesis. These have been especially noticed in connection with the motor centres in the medulla oblongata and spinalis, but also in the gray matter of the cerebrum. The nervous trunks, too, may be the seat of congestion and the fibres undergoing granular degeneration. In one case Eichhorn found the nerve filaments in the seat of the infection wound materially thickened and indurated. This, however, like the occasional redness and congestion in the seat of the cicatrix, is by no means constant. Indications point to the conclusion that the infection extends from the infection wound largely along the nerves. There is the long period of incubation, longer when the bites are in the lower limbs, shorter for the arms, and still shorter for the head; there is the special virulence of the nerves, said to be highest in those of the bitten member (Bardach); and there is the assertion that after inoculation in the sciatic nerve the infectiousness of the spinal cord is found to progress gradually from behind forward (Di Vestra and Zagari). Why paralysis should not develop in the nerves first affected, before the cerebral symptoms set in, does not appear.

The lesions to be specially relied on in both man and animals are the congestion in the fauces and throat, the congested, infiltrated, or ulcerated state of the stomach, the absence of food, but the presence in the dog of foreign bodies and in man of mucus and a débris like coffee-grounds, some congestion of the small intestines, of liver and kidneys, an empty or nearly empty bladder with congested mucosa, mucous or muco-purulent oozing from the various mucous openings, venous congestion and infarctions of the lungs, a black, tarry blood, congestion of the superficial veins, and the congestion of the brain and meninges, with capillary embolisms and minute centres of trophic change. These, with the history of the case, are usually sufficient to identify the disease. It should be added, however, that in the paralytic and lethargic forms in the dog there may be an entire absence of foreign bodies in the stomach.

Symptoms.—*In the Dog.—Incubation* in case of inoculation with potent virus on the brain is six days; in other parts it varies from sixteen to two hundred and forty, with an average of twenty-five days.

Prodromata, which last one to three days, consist in some marked change of habits, with usually restlessness, frequent changing of position, sullenness and irascibility. In other cases the dogs are more confiding and fawning and liable to infect by licking their master or others. There

may be dullness and apathy, but more frequently there is a hyperæsthesia, the dog starting at the slightest noise and crouching as in fear. A tendency to pick up and swallow foreign bodies, like hair, straws, thread, paper, pins, pebbles, dung, dirt, etc., is highly characteristic excepting in puppies, which do this in mere wantonness, The victims eagerly lick cold, smooth objects, as stones, metal, boots, or the nose or genitals of another dog. Sexual excitement and manifest desire for coition are marked. Sudden passion when shown another dog or cat, sudden starting and jumping toward the door, a seeking of darkness and seclusion, and a disposition to leave home and wander away many miles are most significant. The dog will shrink from a blow, yet bear it without a whine, and yet will bark or howl without cause when alone ; the sound is a hoarse, low, muffled one, beginning as a bark and prolonged into a howl, and repeated two or three times in lower tone without closing the mouth. He may tear wood or clothes to pieces, may rub the chops with his paws as if something were in the mouth, may turn the eyes and head as if following some object, and presently snap at it ; he may vomit a bloody material, and he may lick or even gnaw the inoculation wound, which is now liable to become congested, though cicatrized weeks before. The conjunctivæ are reddened and the skin of the face drawn into wrinkles. These premonitory symptoms are the most important ones, since, if they are recognized, the animal may be shut up before he can do any injury to man.

In its subsequent course the malady divides itself into three typical forms—the *furious*, the *paralytic*, and the *lethargic*. The first of these is most common in the less domesticated dogs, while the latter are seen especially in house and pet dogs.

The *furious form* is shown by paroxysms of violence, during which the animal attempts to escape, gnawing at his chain or the doorposts, howling more frequently, trying to bite any creature that annoys him, and even showing a mischievous disposition to attack without provocation. Former human or animal friends are no longer respected, though at first a reluctant obedience may be given to a loved master. If free, the animal may wander off ten or twenty miles, attacking any one in his way, especially if he makes noise or disturbance, swimming rivers, for he has no dread of water, and after the paroxysm he may return home, fawning upon, licking, or even suddenly biting his friends. In this remission he seeks quiet, seclusion, and darkness, until a second paroxysm rouses him to violent effort. But he may be roused at any moment by threatening him with stick or whip, and above all, by presenting to him another dog or cat. In such cases he may tear at a stick or iron bar until his teeth are dislocated and the gums bleed freely. He will even at times bite himself, tearing hair or skin from fore limbs or shoulders, and gnawing the tail, toes, or other part of the body. Food is rejected, or if swallowed may be vomited. The eyes squint or the

dilated pupils give them a peculiar staring appearance as they follow imaginary objects.

Twitchings of the muscles of the face or general convulsions may come on. In two or three days the power of the hind limbs is gradually lost, the hind parts first swaying unsteadily, and finally resting helplessly upon the ground, while the animal still raises himself on his fore limbs. The jaw drops from paralysis, saliva drivels from the mouth, and there is no longer danger of biting. Gradually the paralysis extends to the whole body, and unless interrupted by convulsions this lasts until death on the sixth or eighth (exceptionally the tenth day) from the first symptoms.

In *paralytic* (*dumb*) *rabies* the paralytic stage supervenes at once on the prodromata. The symptoms therefore are essentially those of the culminating stage of the furious form.

In *lethargic rabies* there is neither fury nor at first paralysis, but the animal after the prodromata passes into a condition of lethargy, and remains curled up in a corner, not to be disturbed by threats, punishment, or coaxing; food and drink are alike refused, and the animal drowses along until relieved by death from the tenth to the fifteenth day.

Besides these three forms there are all intervening grades in which one or other of the specific types tends to predominate.

In other Carnivora.—*Wolves*, *foxes*, *jackals*, and *badgers*, overcoming their natural fear, enter villages and cities and bite men and animals after the fashion of the rabid dog. Wolves are especially dangerous because of their strength and ferocity and their disposition to seize on the uncovered throat and face. *Rabid cats* are more retiring, yet easily roused to violence, and use teeth and claws indiscriminately, producing infecting wounds with both. The voice is altered and hoarse, like that made in rut. In all these animals, as in the dog, the violent symptoms merge into the paralytic prior to death.

Symptoms in Man.—*Incubation* is said to be extremely variable in man. In 6 per cent. of all cases it is between three and eighteen days, in 64 per cent. it is between eighteen and sixty-four days, while in 34 per cent. it exceeds sixty days. From fourteen days to two or three months may be said to be the limits. Recorded cases of incubation extending from one to seven years cannot be accepted without the evidence of successful inoculation upon an animal. So frequent in man are cases induced by an overworked imagination (*lyssophobia*) that the very short and very long incubations are to be suspected of belonging to this category until they shall be proved genuine by inoculation on an animal, in which the explanation of a too vivid imagination is inadmissible. No such protracted incubation is met with in any of the lower animals.

At the conclusion of the latent stage the first symptom is usually an

itching, pricking, or pain in the seat of the infection wound, which, though completely healed over, now again becomes congested or swollen. Touching the scar may produce an aura extending toward the body, sighing, or tremor. There may be chilliness, headache, weariness, depression, sullenness, irritability, irascibility, and ungovernable restlessness which impels to constant or frequent movement. There is insomnia or broken sleep with frightful dreams, increasing mental anxiety, sensitiveness even to a current of cold air, and much more to sudden flashes of sunshine, noises, and movements. A tendency to spasms in the throat is shown in increasingly difficult jerking articulations, and some difficulty in swallowing liquids which cause a sense of fulness of the throat and dread of water. The fauces and pharynx are now congested and reddened, as are also the eyes and usually the face. The pulse is somewhat accelerated and hard, but usually small. Breathing is oppressed and accompanied by sighing or sobbing. The mind is clear.

In some cases the malady sets in at once in full severity. The patient is suddenly and unexpectedly seized with spasms of the throat and chest, usually when attempting to drink or when abruptly startled. These are so violent that for the time they threaten suffocation, and from that time on the dread of water is extreme. The sight of a liquid, the sound of it dropping or flowing, the offer of drink, the sight of a smooth surface like glass, will bring on a violent paroxysm. There is not only the feeling of impending suffocation, but a sense of rising of the stomach, with actual retching and vomiting, and a convulsive cough or scream which has been likened to a bark. In the absence of drink a paroxysm may come on in which the predominant sensation is the oppression about the chest and stomach. In all such attacks the face is red, drawn, and distorted, the nostrils and pupils dilated, eyes projected and reddened, and the expression agonized. There are tremors and convulsive contractions of the muscles of the limbs and trunk. The hyperæsthesia is intense, the senses become painfully acute, a bright light, a sound, even of talking, or a slight touch being intolerable. Even in the intervals this continues, and, unless all exciting sights, sounds, or touches can be obviated, another paroxysm is precipitated. The tendency is, however, to a progressive increase of the violence of the paroxysms and decrease in the duration of the intervals, until the patient becomes worn out.

A remarkable and dangerous feature, which like dread of water is peculiar to man, is the spitting out on all sides of the saliva, which can no longer be swallowed. For a length of time the mind is clear, but at the height of the disease the paroxysms merge into fits of mania. The patient charges those about him with having caused his sufferings, and assaults with hands, feet, or teeth any one who approaches. Restraint aggravates this and prolongs the attack. When the paroxysms subside, reason resumes its throne, and the patient is profuse with regrets, apol-

ogies, and warnings for the future. Death often takes place from asphyxia or apoplexy during a paroxysm, and at times suddenly after symptoms of material improvement. The paroxysms vary in length from a half to one hour, and the intervals from a few minutes to several hours. Paroxysms are more violent in the strong and vigorous, in men than in women and children.

Should the patient survive the violent stage, paralysis sets in. The spasms become feebler and finally cease, the breathing is relieved, the hyperæsthesia lessened, and deglutition may again become possible. But debility and prostration increase, twitching of the muscles is seen, the lower jaw drops and saliva flows from the mouth. The breathing becomes rapid and rattling, the voice weak and harsh, the pulse small, rapid, and irregular ; stupor comes on and death ensues, preceded by a state of coma. In exceptional cases the paroxysmal stage is almost or altogether omitted.

The entire duration of the disease in man is from two to four days, exceptional cases being less or more.

Diagnosis.—The diagnosis of the disease is not usually difficult if one finds the history of a bite, the recently healed wound, the intense hyperæsthesia which serves to distinguish it from mania, spasmodic sore throat, epilepsy, and hysteria, and the absence of trismus, which distinguishes it from tetanus. The greatest difficulty is with cases of *lyssophobia*, but in these, as in hysteria, the patient usuallly fails from imperfect acquaintance with the essential symptoms, and cannot get up artificially that extraordinary hyperæsthesia which is so pathognomonic of hydrophobia. Moreover, in nearly all these cases investigation will show a flaw in the history : the animal that bit may be still alive or its death may be uncertain, or it may have been killed by an excited community, or the incubation may have been too short or too long to admit the probability of hydrophobia. An investigation of this history is always in order, and unless there have been cases of rabies in the lower animals from bites made by the animal suspected, it may be opined that the human patient is a victim of *lyssophobia* and to be cured by moral suasion alone.

Prophylaxis of Rabies and Hydrophobia.—The evidence is overwhelming that rabies is always the result of inoculation from a rabid animal or a hydrophobic man ; therefore it is not only possible, but a duty incumbent on every country, to stamp the disease out of existence. Each state should enact and rigorously enforce a law with measures like the following : 1. Register all dogs and tax them heavily ; 2. Have every dog wear a collar bearing a plate inscribed with its owner's name and residence ; let all dogs appearing without such badge be summarily shot by the police or constables ; 3. Let every dog be muzzled in cities and counties that have furnished cases of rabies within a year, and in adjoining counties ; let all dogs found at large unmuzzled be at once

shot by the police ; 4. Dogs and cats bitten or supposed to have been bitten by rabid animals must be promptly killed or shut up in iron cages for six months udder veterinary supervision ; 5. Dogs or cats which have bitten men and are believed to be rabid should not be killed, but shut up in iron cages under veterinary supervision ; if they do not develop rabies, it will be easy by the sight of the healthy animal to protect the bitten person against *lyssophobia ;* 6. Dogs imported from countries other than those from which rabies is excluded (Australasia, etc.,) must be subjected to a quarantine of six months before they may be set at liberty ; 7. Foxes, wolves, badgers, martins, skunks, and other vermin that use the teeth as offensive weapons must be destroyed by poison or otherwise in districts infected with rabies ; 8. The disinfection of kennels and other buildings where rabid dogs or other animals have been must be carefully carried out ; 9. All owners of dogs should be furnished with a circular giving the premonitory symptoms of rabies, and enjoining them to shut up and report any dog showing such symptoms.

The methods of immunizing dogs against rabies are so closely associated with the Pasteurian treatment of the bitten that they will be best considered together.

Treatment of Rabies and Hydrophobia.—The *treatment of the bite* should receive first attention. If caustics are not at hand, the first effort must be to prevent absorption of the poison. If a limb has been bitten, a cord or handkerchief may be tied round above the wound and a stick passed through it and twisted until circulation has been arrested. The wound may then be sucked either through a tube or, if the patient can reach it, with the lips, the mouth being washed frequently with carbolic acid or other antiseptic lotion. Steeping the wound in warm water and wringing it is good as a temporary resort. Drinking of liquids to excess temporarily hinders absorption. As soon as a caustic can be obtained it should be applied thoroughly to all parts of the wound. An iron skewer, nail, or poker at a white heat should be brought in contact with all parts of the wound, and, as the teeth have often met in the flesh, it is usually necessary to pass it clear through between the two external wounds. If chloride of zinc, caustic potash, nitrate of silver, or sulphate of copper or iron is the available caustic, the greatest care must be taken to apply it thoroughly to all recesses of the wound, any fibrous tissue that prevents this being cut through. If mineral acids or other liquid caustics are employed, they may be delivered in the utmost recesses through a pipette or on a pledget of cotton on a staff. When available the galvano-cautery is to be preferred. The parts should be washed with a strong solution of mercuric chloride. Not until the cauterization has been complete should the tourniquet be removed. A delay of several hours or days is no warrant for omitting cauterization. It has always a good moral effect in preventing *lyssophobia*, and as it is almost certain that part of the poison, which is for a time confined to the region of the

sore, is the dangerous portion, it may still be possible to prevent the disease. Senn's advice to excise the adjacent tissues may here be followed, but not to the exclusion of a thorough disinfection. In a very badly mangled limb the only reasonable hope may be in amputation.

In the same line of prophylactic treatment after the bite is the now famous Pasteur method. Rabbits are inoculated on the brain, one from the other, until the disease develops six or seven days after inoculation, the virus having attained to its highest potency. The rabbit infected with this potency is killed, and aseptic sections of its spinal cord are preserved *in vitro*, in free but aseptic air, dried by contact with caustic potassa, for periods varying from one to thirteen days. The virulence lessens from day to day, so that the 13th-day product can be inoculated with perfect safety. The treatment of a bitten person or dog is conducted by giving hypodermically, on the first day, four 2-gramme doses of solutions of the 13th, 12th, 11th, and 10th day cords; on the second day, four of the 10th, 9th, 8th, and 7th; on the third day, four of the 7th, 6th, 5th, and 4th; on the fourth day, two 1½-gramme doses of the 4th and 3d; on the fifth day, two of the 3d and 2d; on the sixth day, two 2-gramme doses of the 8th and 7th; on the seventh day, two doses of the 7th and 6th; on the eighth day, two doses of the 6th and 5th; on the ninth day, two doses of the 5th and 4th; and on the tenth day, two 1½-gramme doses of the 4th and 3d. With two intermissions, on the eleventh and seventeenth days, this is continued until the twenty-sixth day. The best evidence of its efficiency is the fact that in selected cases but 0.54 per cent. of persons bitten and so treated have contracted hydrophobia.

To immunize a healthy subject it is sufficient to give but one dose daily, beginning with the cord thirteen days old, and leaving off with that of the first day. As a remedial agent for the bitten this is unquestionably effective, and has already saved many lives. The objections to it are that it is not aimed at an extinction of the disease, which is the rational course with a pure contagium. It necessitates, on the contrary, a maintenance of the malady for the supply of material. It may also be questioned whether the use of the method, both for curative purposes and immunization, and the setting at liberty of many individuals just injected with the most potent virus known, may not introduce the risk of the conveyance of that germ to others.

Some attempts have been made to escape this last objection. In 1886, I sterilized with heat portions of the spinal cord of a man dead of hydrophobia, and making an aqueous emulsion of the same gave two rabbits three and one rabbit four hypodermic injections of a drachm each on as many successive days. I afterward inoculated them with infecting nervous substance, yet all survived for nine months, while three control rabbits inoculated with the unsterilized nervous substance died rabid.

Tizzoni and Schwarz, finding that the blood serum of an immunized rabbit sterilized a rabic spinal cord *in vitro* in five hours, tested this immunized blood serum on living animals and found that it conferred immunity in the majority of cases. This experiment aimed at securing the antitoxin from another animal, and while it might act temporarily as an immunizing agent and satisfactorily as a curative one when given in large doses, yet as it could not reproduce itself in the animal economy, it must soon be eliminated and the immunity lost. My experiment, on the contrary, aimed at the introduction of the toxic products so as to stimulate the leucocytes and perhaps other cells to a production of the defensive materials which would be continued after the ptomaïnes and toxins have been eliminated. I had already had a successful experience with this method in hog cholera, lung plague, and anthrax, and the favorable results with rabies were therefore to be expected. All such methods, however, should be stopped when a systematic attempt is made for the extinction of the disease.

Fernandez appears to show by extensive statistics and numerous experiments that dogs bitten by vipers are proof against rabies. This would suggest the sterilized poison of vipers as a means of immunization.

All the functions of the bitten person should be maintained in a healthy condition. When possible he should be kept in ignorance of his danger and of the nature of the disease should it develop. He should be among calm, cheerful people, who will never refer to the matter nor allow the subject to see that they are any way anxious. If the matter does come up, full confidence in the protective measures adopted should be claimed. Every cause of excitement should be avoided.

When the disease has developed, the patient must be kept in perfect seclusion, quiet, and darkness, and out of currents of air. Antispasmodics and nerve sedatives may be given by the rectum, hypodermically, or by inhalation to relieve the sufferings, though there is little hope of their obviating a fatal result. Agents like chloroform, chloral, and the bromides, which lessen cerebral congestion, are on that account to be preferred. As a therapeutic agent the blood serum of strongly immunized rabbits would hold out more hope than anything known, yet it is doubtful how far this can be relied upon when the disease is already developed. In undeveloped cases approaching the end of incubation this might be employed in connection with the intensive inoculation of Pasteur.

ACTINOMYCOSIS.

Pp. 775-784.

DEFINITION.—A chronic infectious disease of man and animals, induced by the growth in the tissues of actinomyces (ray fungus), and usually manifested by hyperplastic swellings resembling sarcomata.

Animals Susceptible.—It occurs casually in herbivora and omnivora —cattle, swine, horses, and elephants—and in the human being, and very exceptionally in the dog. Experimentally, it has been produced in a number of genera, including rabbits, guinea-pigs, dogs, cats, sheep, and goats. It is probably a question of exposure, as the dog is easily infected, and cultures from the dog on artificial media grow with great vigor.

ETIOLOGY.—The essential cause is the implanting of the actinomyces in the tissues, hard (tooth, bone) or soft (connective tissue, muscle, parenchyma).

Among accessory causes caries and fractures of the teeth, and the exposure of raw surfaces on the gums and alveolæ in connection with the shedding of the teeth, are prominent factors. The alveolæ of the tonsils, the ducts of salivary and other glands, raw sores, wounds, running abscesses, and fistulæ afford a lodgment for the cryptogam and an opportunity for development. The germ may enter through a protoplasmic cell into the lymph spaces and form a primary focus in the lymph gland, but this is exceptional. Barley awns from their imbricated surface work their way readily into soft tissues and afford starting points for infection. Glumes of barley and other cereals, wheat bran, and other vegetable products have often been found in the tonsillar cavities, gums, etc., (Johne, Piana, Korsak), and on the tongue (Bodamer), along with the parasite. Jensen found the parasite growing on rye, and Liebmann, who inoculated it on grains, found that it started growth with the germination of the seed, and, growing with great energy, pervaded the entire plant. It must not be inferred that the actinomyces is confined to the cereals for its vegetable hosts, since it is not unknown in the cattle of North American plains, which live mainly on buffalo grass and never see grain.

The areas of special prevalence of actinomycosis are mostly low, damp, and rich in decomposing organic débris. Thus the disease may be said to be enzoötic in the fens of England (Norfolk and Lincoln,

Crookshank), in the river-bottom of the Brora in Scotland (Dick), in the polders of Zealand (Jensen), in the low lands in Marienburg and Ebling near the mouth of the Vistula (Preusse), and in the rich, uncultivated steppe lands near the Volga (Mari) and Dneiper (Korsak). One farm in Peoria county, Illinois, furnished 17 cases of actinomycosis in a herd of 80, and on a damp delta on Cayuga Lake, New York, I have found three bovine generations affected—granddam, dam, and daughter. This must be qualified by the statement that cases are more numerous in dry seasons, as they are also in winter, because in eating dry, withered fodder wounds of the mouth and throat are more common.

Youth predisposes strongly, mainly because it is the period of teething and of raw sores in the mouth, and partly because the tissues are more delicate and easily penetrated, and because more or less congestion is determined by sucking.

Thrush (most common in youth) and other forms of stomatitis open the way for infection, and in Europe cases increase greatly after an epizoötic of *foot-and-mouth disease*. In such cases the primary lesions are usually in the soft tissues (tongue, cheeks, and face), whereas in connection with diseased teeth or gums the jaws are the first to suffer.

The disease appears to have greatly increased in the herds of the Mississippi Valley of late years, the infection atria being furnished by the scratches, of the head and neck especially, by the barbed wire fences.

Actinomyces Streptothrix.—Actinomyces was found in the diseased jaws of cows, and studied by Perroncito in 1863, by Rivolta in 1868, and by Hahn in 1870. Bollinger was, however, the first to demonstrate its constant presence in the sarcomata of the jaws of cattle and to claim its etiological significance. Johne next inoculated the actinomyces from the cow into the abdominal cavities of two calves and mammæ of a cow. Ponfick produced a case of pulmonary actinomycosis by intravenous infection. In 1878, Israel reported two cases of actinomycosis in man with successful inoculation on animals. Langenbeck had, however, already in 1845 found the characteristic tufts in the pus from a carious human vertebra, and Lebert, in 1848, in the pus of a thoracic abscess.

Morphology.—As seen in the animal tissues, the actinomyces consists largely of branching filaments and of the characteristic round clusters or tufts. The latter are the most important diagnostically, as they are not really microscopical, but vary in size from a small grain of sand to a pin's head (0.1 to 0.5 mm.). They have a yellowish, often bright sulphur-yellow color, and may be calcified, hard, and gritty. Decalcified and cut in sections or broken down and stained, they are seen to consist—1st, of a dense central mass of interlacing filaments; and 2d, connecting with the latter, of an outer cortical layer of pyriform or club-shaped bodies terminating externally in rounded ends packed closely together like the seeds and pericarp of a strawberry, and continued by their attenuated inner seeds into the central mycelium. This large clus-

ter, like a daisy head, is the rule, but it is not invariable. A filament sometimes terminates in a single club-shaped cell or divides into two, three, or more, while some will grow through a tuft and divide to form tufts some distance beyond. In the central felted mass are numerous cocci in groups or chains, and the free ends of the pyriform cortical cells may be surrounded by spherical granules (hyaline bodies), variously described as spores and degeneration products. They stain by Gram's method. If difficult to find in thick gelatinoid pus, that may be first cleared up by caustic potash.

Actinomyces is anaërobic, but grows well in the bottom of stab cultures in glycerined or glucosed agar or gelatin. If accustomed to grow in free air, it loses its pathogenic quality, which may partly explain its prevalence on close, rich, waterlogged soils from which the air is excluded. In dry, porous soils the harmless aërobic habit must be much more common.

Habits of growth and pathogenic potency vary much with different conditions in artificial cultures. The tufts are often absent, yet the product inoculated on animals produces these as before. Gasperini not only obtained different forms from the same stock but he observed that forms apparently identical under the microscope varied greatly in pathogenic power according to the conditions in which they had been cultivated. The virulence was further largely affected by the greater or lesser reaction of the animal tissues invaded.

Actinomyces differs from the streptothrix of Madura foot, in that it is cosmopolitan, is not confined to man, and it is not restricted to foot and hand, but attacks all regions progressively and indiscriminately. Its behavior in artificial cultures is also entirely different.

Pathological Anatomy.—Aside from the actinomyces with its characteristic yellow tufts, the pathological formations are like sarcomata. The parasite is chemiotactic, causing a great accumulation of embryonic and giant cells which are imbeded in a fibrous stroma of varying abundance, and determining a great diversity of consistency in different neoplasms. Some are very friable; others are as hard as gristle (holzzunge). The spherical and rodlike elements of the parasite, and even the clubs, enter the interior of leucocytes, and are sometimes carried by these to form new foci at a distance from the primary one. The disease may be cut short by the destruction of the parasite through phagocytosis, or molecular necrosis may ensue in the neoplasm, or suppuration may take place, developing an abscess in the centre, in the walls of which the actinomyces may continue to proliferate and advance. It is characteristic of the hyperplasia that it tends to invade all surrounding tissues indiscriminately, though advancing in soft tissues more rapidly, and that it only exceptionally implicates the adjacent lymphatic glands until tissue in contact with them has been involved. This serves to distinguish it from cancer, tuberculosis, and other diseases.

Actinomycosis in Man.—As already stated, Langenbeck found the actinomyces cells in 1845 in a carious vertebra of man, and Lebert in 1848 in the pus of a thoracic abscess. In 1877, Bollinger published his cases in cattle, and the following year J. Israel recorded two cases of actinomycosis in men, adding a third in 1879. New cases were soon recorded, and in 1882 was published Ponfick's work, *Die Actinomykose des Menschen.* Up to the present date some hundreds of cases have been recorded, including the invasion of the most varied organs of the body, though, as in cattle, a decided preference is shown for the vicinity of the teeth, the jawbone, face, and neck.

Actinomyces Hominis and Actinomyces Bovis.—In view of the pleomorphism of actinomyces and the variations caused by growth in different media or genera, it is difficult to decide upon the identity of these, yet the frequent inoculation of calves as well as rodents with the specimens obtained from man clearly shows that the human and bovine host can propagate the same parasite. As the morphology in man and the ox is practically identical, it is useless to repeat what has been recorded above. (See page 776.)

Etiology.—In the main, man derives the disease from the same sources as the animal, yet the facts that he habitually cooks his food, and is not subject to the buccal injuries which come from the consumption of hard fibrous vegetables and raw grains, serve to protect him from the marked prevalence of the disease shown in cattle in actinomyces districts. The influence of dentition and carious teeth as etiological factors is seen in the frequency of primary actinomycosis in the jaw and face, and especially at an early age. The case of lung actinomycosis with a particle of carious tooth imbedded in the growth is equally significant. The direct action of barley awns has been frequently noticed. In Soltman's case the awn lodged in the pharynx, interfering with swallowing; then it penetrated the mucosa, causing hemorrhage; after this it made its way through the tissues, developing an actinomycotic phlegmon in its course, and was finally extracted through a fistula formed below the scapula. Buzzi records a case of actinomycosis of the neck extending from a decayed tooth and enclosing a straw beard in a cervical cavity. We may conclude that, as in animals, so in man, the germ is usually introduced through the food, air, or water.

Against infection through eating the flesh of actinomycotic animals man is largely protected—(1) by the cooking of his food; (2) by the impaired vigor with which the parasite grows when transferred directly from animal to animal. But that there is danger of such an infection cannot be ignored. The successful transference from man to animals implies the possibility of conveyance from animal to man. Certain recorded observations, indeed, have been thought to be cases of this kind. Baracz instances the transference from man to man, and Barnard from cattle to man. O'Neil records the case of a farmer who con-

tracted actinomycosis after dressing calves suffering from a disease of the skin; Bergmann, a case affecting the orbit of a man who handled a diseased cow; Munch, the case of a man with pulmonary actinomycosis who had fed for three years an ox having this disease in the jaw; Oschner, the case of a farmer and cattle-dealer who treated his "lumpy-jaw" cattle with arsenic, and contracted actinomycosis of the antrum and facial bones, and of a second Illinois farmer who treated his Oregon pony for "lumpy jaw," and himself contracted the disease in antrum and face.

Pathological Anatomy in Man.—This does not differ essentially from what has been already described in cattle. The presence and growth of the parasite cause a local phlegmonous inflammation, with an extraordinary accumulation of embryonic and giant cells in a stroma of fibrous tissue. There is an attraction of leucocytes to the microbe, and a process of phagocytosis is established which may result in the destruction of the parasite or in necrobiosis of the tissues. If the latter, the disease goes on slowly spreading into the surrounding tissues, invading their structure rather than pushing them aside, and from this, as well as from its induration in chronic cases, it has often been mistaken for carcinoma. The actinomyces does not seem to be of itself pyogenic, and when lodged deeply in the tissues may progress for months without suppuration. When, however, the diseased focus is invaded by pyogenic bacteria through the primary infection wound or through the swelling reaching the surface in the course of its natural increase, the progress of the disease is thereafter more rapid, the destructive action of the pus microbes evidently paving the way for a freer growth. The gravity of the case, therefore, bears a close relation to the early occurrence of suppuration and fistula or to cutaneous ulceration. As in cattle, the disease process bears a close resemblance to that of the round-celled sarcoma, and is only to be distinguished by the presence of the actinomyces tufts with their central mycelium and periphery of clubshaped cells. In man, too, the disease tends to a chronic form, and generally remains confined to its primary focus for a length of time.

Localization and Symptoms in Man.—Infection may occur through any breach of continuity of skin or mucous membrane, and such breach may be caused by the growth of the actinomyces in a natural cavity like the alveoli of the tonsils or the ducts of glands. Primary foci, therefore, mostly appear in connection with skin or mucous membrane.

(1) *In the Skin.*—Ponfick records one case starting from the bite of a louse; Majocchi, one originating in a wound of the skin; Partsch, one following the excision of the breast in a man of sixty years; Hochenegg, one on the skin of the lower jaw following atheroma; and Kaposi, one in the right axilla. Lesser, who met with three cutaneous cases, found that scattered nodules appeared around the primary lesion, and the con-

nection could be traced through passages corresponding in size to a lead pencil and filled with yellowish gray or reddish gray granulations, the tissues undergoing molecular destruction as these advance.

Kaposi's case began with a red spot the size of a florin, which grew to the size of a walnut, and then slowly flattened and disappeared, but not until new spots and nodules had formed around it, some as large as a pigeon's egg. The advance was slow for eleven years, when a swelling as large as an apple formed on the spine of the sixth vertebra, extended forward into the axilla, and finally ulcerated, exposing a soft fungous bleeding surface in which the tufts of actinomyces could be detected. Meanwhile nodules had appeared very generally over the trunk and lodged in the corium.

(2) *In the Teeth, Gums, and Jawbones.*—Cases are recorded in which a carious cavity or periodontal abscess without manifest swelling of the bone furnished the characteristic clubshaped cells (Israel, Partsch). From such centres the disease spreads to the cancellated tissue of the bone or periosteum, with resulting swelling of the lower, or less frequently of the upper, jaw. In such cases violent toothache sets in with swelling of the jawbone, and most commonly a fistulous opening discharging actinomycotic pus. Israel records one such case in a woman of forty-six in which the swelling, as large as a cherry, was twice laid open and the diseased granulation tissue scraped out before permanent healing was secured. In another case the disease in five months extended from the lower jaw to the level of the thyroid cartilage. When the lesion extends along the periosteum or the superposed soft tissues to the neck, it often makes increasingly rapid progress on reaching the loose connective tissue of that region. When it extends in the cancellated bone, the teeth are loosened, and often all the molars in the affected jaw are extracted to relieve the attendant suffering. Murphy met two such cases in the Chicago Hospital, one in a woman of twenty-eight and the other in a man of eighteen. The woman had violent toothache, with swelling in the throat and difficult deglutition. These improved under poulticing, but returned with the addition of enlarged tonsil and swelling at the angle of the jaw, and a second swelling below on the side of the neck. The latter and the swelliug in the tonsil were lanced, giving exit to actinomycotic pus. The removal of a carious tooth revealed a fistula leading from the alveolus to the external wound. The diseased masses were now scraped out and the cavity filled with iodoform gauze, and recovery ensued.

Senn furnishes two more cases from the Milwaukee Hospital. They had each lasted over five months, and all the molars of the jaw on the affected side had been extracted. In the first case the edentulous alveolar border of the lower jaw, from the first bicuspid backward, presented a continuous fungous mass, suppurating freely and with openings at intervals discharging actinomycotic pus from deep-seated abscesses.

The cheek was enormously swollen from the angle of the mouth to the lower margin of the parotid, the swelling fading gradually into the surrounding tissues. An incision was made the whole length of the ramus of the jaw, the alveolar processes removed with forceps and chisel, any diseased surface of bone scraped, the diseased soft parts dissected out, the bone cauterized, and the wound packed with iodoform gauze. Great improvement followed, but six weeks later abscesses formed reaching from the jaw to the clavicle and scapula, numerous fistulous openings appeared, and the patient weakened and died. In the second case there was no open sore, no double infection by the introduction of pus microbes, and the patient recovered. The disease connected with the edentulous posterior alveoli of the upper jaw and the swelling of the soft parts extended from the zigoma to the lower border of the maxilla. When laid open the whole cheek seemed to be changed into granulation tissue in which the yellowish gray actinomyces tufts were found. This was thoroughly removed and the jawbone scraped and cauterized.

In a case treated by Bodamer in the German Hospital, Philadelphia, the lesions extended from the right lower maxillary bone, where he had had the three back teeth extracted, downward upon the neck and upward upon the temporal region, with the formation of fistulous openings at intervals. The case was a chronic one, the maxillary swelling, which had previously advanced and receded alternately, "coming to stay" in 1882, and the patient coming to the hospital in 1889.

The growths have a tendency to migrate, a swelling which at first shows on the gums being found later at the angle of the jaw or elsewhere. This seems to imply the death and removal of the actinomyces near the seat of infection, while the newer and more vigorous growth is advancing into new tissue.

(3) *In the Tongue.*—Hochenegg mentions a case of a cherry-sized actinomycotic swelling near the tip of the tongue infected from a carious tooth, which had apparently served as a traumatic agent as well. Henck saw a case of tongue actinomycosis with secondary lesions in the chest walls and vertebræ. Three other cases are on record—one primary, one secondary, and one metastatic.

(4) *In the Intestinal Canal and Abdomen.*—Primary actinomycosis of stomach or bowels occurs from the ingestion of the actinomyces with food or water. Getting imbedded in an abrasion, gland duct, or in the alveoli of the solitary or agminated glands, the parasite grows and advances into the mucosa and deeper parts. Osler records a case affecting the small intestine; Kopfstein and Lanz, cases in the ileo-cæcal region; Redtenbacher, Chiari, and others furnish additional cases. In Redtenbacher's case a young woman had a swelling like the fist in the epigastrium, and the mesogastrium firmly attached to the abdominal walls, and with a second apple-like mass felt behind. It grew rapidly from its first appearance in early summer and proved fatal in autumn. A fistula from

the intestine extended into the muscles and subcutaneous connective tissue; Douglas's pouch was full of pus; and the ovaries, Fallopian tubes, and uterus were implicated. Chiari's patient was an emaciated man of thirty-six. At the necropsy was found chronic tuberculosis of the lungs and ileum. The mucosa of the cæcum and colon was catarrhal, with numerous firm round or oblong patches 1 centimetre in diameter by 5 millimetres thick, containing yellow actinomyces tufts. Zemann furnishes four cases of perforation of the walls of the intestines and formation of extensive abscesses in the peritoneal cavity, communicating with fistulous openings in the abdominal walls. These cases were characterized by acute abdominal pains and great tenderness of the abdomen. Leuning and Hamm furnish a case of primary actinomycosis of the colon and secondary formations in the liver, and Langhans one affecting primarily the veriform appendix, but extending to the bladder and liver.

The *liver* is usually affected secondarily to other abdominal organs. In one case of Sharkey and Ocland, however, it appeared to be the primary seat of disease. The patient, a joiner, thirty years old, was very pallid and emaciated, and a painful tumor like an orange projected forward in the right hypochondrium. This with a similar tumor in the right loin was successively incised, evacuating a very little pus and blood, but the patient continued to sink and died on the seventieth day. At the necropsy were found the two abscesses communicating with the incision, but considerably diminished. The liver, five pounds three and a half ounces in weight, contained numerous globular antinomycotic masses, between which the hepatic tissue was soft, white, and shreddy. The left lobe was adherent to the abdominal walls and communicated with the upper incised tumor and fistula.

Mr. Shattuck gives two museum cases in which the actinomycotic abscesses in the liver were associated with adhesions and thickening of the omentum and pelvic peritoneum in one case, and in the other with tumors of the ovaries, Fallopian tubes, and adjacent parts. The latter case had invaded the right pleura through the diaphragm, to which the liver was attached.

Knur reports the case of a man of thirty who had worked in the Union Stock Yards, New York. Later he began to cough, lost strength and vigor, and had pains in the right side. A swelling formed in the right hypochondrium, which was lanced but yielded only a bloody liquid débris. Similar swellings followed at intervals, but their incision gave no better results, and the patient became very pale, emaciated, and weak. In the discharges were found actinomyces tufts, and an operation was attempted, but the patient died of shock.

A case involving ovaries and liver is reported by Stewart and Muir, and one affecting the liver and lungs by Taylor. Cases involving the urinary organs are reported by Langhans and Ransom.

(5) *In the Chest and Air-passages.*—Majocchi saw a case in which the mouth and larynx were simultaneously affected. Actinomycosis of the lungs has been frequently observed, the germ having been evidently inhaled. In one case, however, Israel found a fragment of an infected carious tooth in the centre of the lung lesion. The diagnosis may be made by observing the actinomyces tufts or clubs in the expectoration in cases affecting the bronchial mucosa and attended by symptoms of fœtid bronchitis, and also in extensive deposits in the lung tissues and cavities communcating with the bronchia. The actinomyces must not be confounded with cells and mycelia of leptothrix or aspergillus. In other cases with adhesions of the lung and the formation of a fistula through an intercostal space the discharge may identify it. In those forms, however, in which there are miliary deposits only in the lung tissue it may be impossible to diagnose it from tuberculosis excepting by a resort to tuberculin as a means or inducing reaction. In most cases, however, pulmonary actinomycosis is associated with lesions in other organs, which materially help in diagnosis. Fever, though usually present, is variable according to the extent and activity of the inflammatory action and the invasion of pyogenic microbes.

Primary actinomycosis of the lungs is recorded by Munch (1 case), Canalie (1 case), Ullmann (1 case), Hanan (2 cases) and Jekenovitsch (1 case). Netter furnishes two cases, of the pleura and posterior mediastinal glands respectively, in both of which the lungs were sound. In other cases the vertebræ and walls of the chest were the seat of the lesions as an extension or metastasis from other parts. Dor cites the case of a man with primary lesions in the jaw and secondary in the lungs. Szenasy, on the contrary, records the case of a butcher's wife with carious teeth, but no appreciable actinomyces, who had suffered for nine years from a violent cough and severe pain in the chest, together with a growing and slightly fluctuating swelling on the right breast in the third intecostal space. Liquid drawn from this by aspiration showed actinomyces.

(6) *In the Brain.*—Bollinger records a case of primary actinomycosis of the brain in a man of twenty-six. There were severe headache, paralysis of the left abducens, congestion of the optic disk, and intervals of momentary unconsciousness. The lesion was found as a cysto-myxoma in the third ventricle, with affusion in all the ventricles. Two cases of secondary brain actinomycosis are reported by Keller and Gamgee and Delépine. Keller's patient, a woman of middle age, suffered from pleurisy, which in six months led to pointing of an intercostal abscess, with actinomyces in the pus. Two years later she had paresis of the left limb and side of the face, convulsions, and epilepsy, for which she was trephined, with temporary relief of the paralysis, followed by death a few days later. A mass of granulation tissue over the right frontal and parietal convolutions extended an inch into the brain, and beneath was an abscess as large as a nutmeg containing actinomyces. In the case

of Gambee and Delépine there were left pleural effusion and a hepatic abscess containing actinomyces, and in the frontal, parietal, and temporo-sphenoidal lobes of the brain a mycelial growth without clubs.

Diagnosis.—While the symptoms will vary according to the organ invaded, and the correct diagnosis will always rest finally on the presence of the actinomyces in the lesions, yet there are certain indications which should lead to the suspicion of actinomycosis and consequent microscopic investigation. First, actinomycosis is habitually chronic: when it develops rapidly there is usually the early formation of abscess, in which the actinomyces are found. The specific product apart from the parasitic growth, is granulation tissue, small round cells, and giant cells, in a fibrous stroma of variable density, and it increases like a tumor, with comparatively little pain or tenderness, rather than like an inflammatory swelling. In advancing it invades the tissues indiscriminately, in this respect resembling a cancer. It differs from cancer, however, in its usual development under the integument, and in its invading the skin from within outward, whereas cancer tends to extend from the epithelial layers inward. It further differs from cancer, and equally from tubercle, syphilis, and glanders, in its indisposition to form secondary lesions in adjacent lymphatic glands, whereas in these other diseases such neoplasia in the glands are to be expected. As a further diagnostic symptom of tuberculosis and glanders, the injection of a small dose of tuberculin or mallein may be employed to produce febrile reaction in case one of these diseases is present. The patient's consent to the risk of such temporary aggravation of his disease should of course be obtained.

Prophylaxis.—In considering the wide range of causation it stands out clearly that certain soils are culture fields for the pathogenic actinomyces, and indications point to drainage and aëration of such soils as sanitary measures. If this is impossible, the soils should be withheld from pasturage or raising forage crops, especially such as are to be consumed by young teething stock and during winter. Foods raised on such soils for the use of man may be sterilized by heat. Actinomycotic cattle should be promptly destroyed or subjected to curative treatment, as the escaping seeds, whether dried up and conveyed on the air to food and water or lodged on vegetation or soil where they can grow and multiply, are calculated to increase the danger. The stables where diseased cattle have stood, above all the stalls and mangers, should be deluged with boiling water or treated with steam under pressure, and then soaked in a solution of 1 ounce of sulphate of copper in 8 ounces of water. The discharge from actinomycotic sores should be burned or disinfected. An important precaution is for human beings in actinomyces districts to maintain a healthy condition of the teeth and gums. Animals with actinomycosis should not be killed and marketed as dressed beef, but subjected to curative treatment. The carcass may, however, be safely marketed as canned meat.

TREATMENT.—Formerly actinomycosis was treated by surgical means only, embracing the excision of the tumors or later the scraping out of the granulation tissue with a strong sharp spoon, and the application of caustics to the cavity. Strong solutions of sulphate of copper proved very effective for purely local lesions, but manifestly such measures were useless for lesions of important internal organs. Since Bollinger's demonstration of the microphytic cause of the disease I have resorted to iodized phenol, applied on tow or cotton to the cavities, after scraping out the diseased masses as completely as possible. This proved most efficient even in the worst local cases, the agent being at once a more efficient parasiticide than the copper, and a less destructive agent to sound tissues. In 1885, Professor Thomassen of the Veterinary College of Utrecht resorted to large doses of iodide of potassium internally, and by the use of this agent the disease has been virtually robbed of its terrors. It has now been very extensively applied in both Europe and America to cattle in all stages of the disease, and in the main with success. The most extensive test was by the Bureau of Animal Industry upon 185 cattle in all stages of the malady, and of which 131, or 71 per cent., rapidly and completely recovered. In all recent and moderate cases a cure is to be expected. It would, however, be unwise to omit local treatment wherever that can be applied. The swellings should be cut out or scraped out to their depth and the cavity filled with stupes saturated with iodized phenol. The iodide of potassium should not exceed 1 gramme (16 grains) for every 100 pounds of live weight of the animal. This is given daily for four or five days, when iodism will be shown by free secretion from the nose and eyes and some inappetence and costiveness of the bowels. A laxative diet and doses of laxative medicine will prepare the animal in two days for a second week's treatment, and a similar preparation will fit for a third, until the disease is cured. Recovery may be completed in from five to seven weeks. In man 20 to 30 grains daily has proved equally effective, even in apparently aggravated cases. The good result appears to depend on the destructive action of the iodine on the parasite, an exact parallel to its action on the achorion Schönleini of ringworm. Norgaard has cultivated actinomyces in gelatin containing 1 per cent. of iodide of potassium, but in the animal system the microphyte has already met with an inimical agent in the phagocytes, and it is only necessary to reinforce this by the internal iodine medication to put an end to its propagation in the tissues.

VETERINARY SCHOOLS IN THE STATE.

Editorial in Turf, Field and Farm, April 22, 1898. P. 517.

The New York State Veterinary College is located at Ithaca on the campus of Cornell University, and the Legislature has voted thousands of the people's money to equip it and keep it going. The announcement for the coming year gives the class for 1897-1898. There are five third-year students, only one of whom is from New York; eight second-year students, six of which are from Ithaca and four first-year students. This is a very weak showing for the amount of money expended. What is the cause? The standard of admission to this and other veterinary colleges in the State has been made so high by the Board of Regents as to practically bar the majority of young men who aspire to the practice of veterinary medicine. A certificate of 48 academic counts is required to enter. The number of counts represented by each subject is: English, 8; geography, physical and political, 2; drawing, 2; American history and civics, 2; plane geometry, 4; algebra, 4; elementary French, 4; elementary German, 4; Latin, Caesar and Grammar, 8; chemistry, 4; and geology, 4. This is a formidable list, and it is pronounced unreasonable by some of the foremost scientific men in the State. If the Regents do not reduce the number of counts the Legislature should take the matter in hand next Winter. It is absurd to spend the people's money in such a way as to furnish such insignificant results. While the veterinary colleges of this State are being strangled by the action of the Regents, those of other States and of Canada are doing a flourishing business. Students unable to pass a preliminary examination here find no difficulty in entering the schools at Toronto, Montreal and elsewhere.

PROF. LAW ON VETERINARY SCHOOLS.

Reply to Editorial in Turf, Field and Farm. April 29, 1898. P. 552.

NEW YORK STATE VETERINARY COLLEGE,
CORNELL UNIVERSITY,
ITHACA, N. Y., APRIL 22, 1898.

Editor Turf, Field and Farm:

In common with other teachers, I am glad to see the interest shown in veterinary education in the article on "Veterinary Schools in the State." But there are certain points which the writer of that article does not seem to have had before him, and that are important, if we would reach an intelligent conclusion on the subject.

First, the Regents demand 48 academic counts for matriculation, but they do not demand that these shall be the subjects named in the article. Excepting the 8 counts in English, which are compulsory on all, the candidate may select any group of subjects taught in a high school, and if he can present 40 counts in these in addition to the 8 in English he will be accepted. As indicated by the Regents' examinations handbook, it seems as if the student might take 38 counts in English alone, and the remaining 10 counts might be taken in arithmetic, geography, drawing and other simple subjects, without a single foreign tongue or hard, scientific study. "The rule is (page 9 of our "Announcement"): "Regents' pass card for any 48 academic counts."

It is perfectly true that hitherto certain veterinary schools have admitted students with practically no preliminary examination. But the men who could not have taken such preliminary examination are handicapped for life, unless they can overcome their deficiency by hard work in the future.

When a veterinarian has been wanted to undertake scientific work, as in agricultural and experiment stations, the choice has almost invariably fallen on one who has a bachelor's degree; or, at least, what our New York law demands for matriculation in a veterinary college.

If we turn to the European veterinary schools we find that all demand an elaborate matriculation examination; in five cases Latin is obliga-

tory, and in several one other language in addition to this and the native one. Then the professional studies in these European schools extend in different cases from three and one-half to five years, of at least nine months each, and it is a very common thing for the student to stay an extra year because he cannot accomplish the work in the time prescribed.

If we are to learn anything from the experience of the Old World and the demands of the New for scientific veterinary work, the lesson would seem to be unquestionably that our average American veterinary college has lagged behind and is failing to fulfil the demand of modern medicine and of our immense live-stock industry. The domestic animals furnish as many different genera in America as in Europe. They suffer from the same diseases ; or, if we lack one or two that are common in Europe, we can furnish at least a corresponding number which are peculiar to America. We yield to no European country in the numbers or values of our live-stock. Why, then, should the guardians of their health and of our public health to be one whit less accomplished or efficient than those entrusted with the same duties in Europe ?

This is not and should not be a question of the survival of this school or that ; it is and must be the question of how to best contribute to the welfare of our great live stock interests. In making the transition from the methods of the past, which are no longer in keeping with the medicine of the present and the future, some inconvenience must come to the existing schools; but if these will loyally stand by the higher requirements the New York schools will soon find that they will secure a new demand for graduates from the country districts, which have been supplied hitherto by graduates of alien colleges with still lesser requirements, and our live-stock will secure the care of more accomplished men in disease and health. In place of being strangled by the New York law, our colleges will enter on a new career, higher and better than before, and the sanitation of our herds and markets will be more thoroughly secured.

To go back to our former system will, perhaps, bring an immediate influx of students, but it will entail a lower type of veterinarian ; It will defeat its own end by admitting from schools outside of the State a host of students moving on a still lower plane, the interests of our live-stock industry will correspondingly suffer and American veterinary medicine will be kept for an indefinite time far below that of Europe.

Because Toronto and Montreal have fallen far behind the lead of Europe is certainly no reason why we, too, should forget that we are living in the last years of the Nineteenth Century.

Yours, etc.,

JAMES LAW.

DANGERS TO MANKIND FROM THE CONSUMPTION

OF THE

FLESH AND MILK OF TUBERCULOUS ANIMALS.

DANGERS TO MANKIND FROM THE CONSUMPTION OF THE FLESH AND MILK OF TUBERCULOUS ANIMALS.

BY DR. JAMES LAW, ITHACA, N. Y.

The subject assigned me opens a wider field than I am inclined to cultivate at present. So I shall make a selection of a few points only which may be fairly included in the general subject. I propose therefore to place under separate headings some thoughts on issues which I believe to be live and urgent to-day.

THE ORIGINAL IDENITY AND ESSENTIAL UNITY OF THE BACILLUS TUBERCULOSIS.

Probably, as no one denies this proposition, yet you will bear with me if I state succinctly a few of the conditions which serve to establish this identity. For if all branches of bacillus tuberculosis have come from one common primary stock and if all the varied manifestations of tubercle are but different forms of the same essential morbid condition, it cannot be safely claimed that the seed of the different branches is incapable of developing a product like the same original stock.

1st. The bacillus tuberculosis, from whatever animal derived has a similar, apparently an almost identical morphology. 2nd All alike have peculiar staining properties, which distinguish them from all other pathogenic organisms except the bacillus leprae and the smegma bacillus, the lesions of which cannot be confounded with tubercle. 3rd. Its viability and destructibility ; its thermal death point ; its destruction by light ; its survival of drying, freezing and putrefaction ; its propagation through dust, agree no matter what the source from which it was obtained. 4th. In the general susceptibility of a great number of genera of animals to the inoculated germ, and in the special susceptibility of of the common experimental animals like rodents to the germ as derived from different animal sources, we have another strong evidence of an essential unity. 5th. In the usual seats of election for the propagation of the bacillus in the bodies of different

animals, and irrespective of the animal from which the virus was drawn, we find another indication of primary and essential identity. The preference of tubercles for the lymph glands, lymph plexuses and lymph sacs or serous membranes is a characteristic that need not be specially insisted on. 6th. The close similarity of the lesions caused in different animals by the bacilli drawn from the different genera bespeaks an essential identity. The congested miliary nodule or tubercle, with the excessive production of nests of small rounded cells, which tend to degeneration, necrosis and caseation, is essentially the same in all, and while it may be mimicked by certain other lesions such as glanders, it is so in none other having a germ bearing the same characteristics as those of the bacillus tuberculosis. 7th. In all forms of the disease, and from whatever source the bacillus may have been derived, there is the same tendency to a slow evolution of the morbid lesion. 8th. The bacillus tuberculosis from any genus of animal demands for its artificial culture a special culture-medium, glycerined or glucosed as the case may be, while it refuses to grow readily on the common culture media of the laboratory. 9th. The bacillus drawn from any genus of tuberculous animal grows with remarkable tardiness, and does not attain a full development until at the end of about two months. 10th. The culture medium of the bacillus from any genus of animal,—man, ox, or bird,—becomes charged with those products which are collectively known as tuberculin, and to all cases alike these act on the tuberculous system in the same way causing hyperthermia and other nervous disorders. It matters little whether the bouillon had been seeded from the tubercle of man, ox, bird, ape or bear, the resulting tuberculin can be used with confidence in testing for tuberculosis, in any animal.

This ought to be enough to establish the primary and essential unity of the germ. It is useless to ignore the fact that special minor differences may be established between two varieties of the bacillus which have respectively lived for a length of time in two widely different genera of animals, but the original and fundamental unity must be held to more than counterbalance this temporary and slight diversity. The single fact that the hypothetical parent germ has contained the potentiality which evolved under different environments into what we may perhaps admit to be two varieties, virtually establishes the possibility and the probability of the reversion to the original type, when the environment changes and becomes like that in which the original or parent

germ was produced. The elasticity of type in nature and the adaptability of an organism to its environment is a fact which we must always keep in view, in the field of pathology and in what we are pleased to call the normal. But it would be alike illogical and unscientific, to hold to this plasticity of type in one direction and to ignore or deny it in the opposite. If an organism is capable of evolution it must be equally capable of retrogression. The very claim of the evolution of a special variety of the bacillus, therefore, is the best possible evidence that that variety has not become harmless under all conditions to the host from the bacillus of which it has varied.

TRANSMISSION OF TUBERCULOSIS FROM MAN TO ANIMALS AND FROM ANIMALS TO MAN.

The whole history of experimental tuberculosis consists in the conveyance of tuberculosis from animal to animal, from one genus of animal to another, and from man to the lower animals. The experimental animals have been mainly rabbits, Guineapigs, rats, mice, dogs, cats, cattle, sheep, swine and less frequently horses and birds. Apart from the avian tuberculosis, the experimental infections, by inoculation, feeding and inhalation, have been so successful, not to say constant, that the conviction of the essential identity of the bacillus in the different quadrupeds has been generally accepted. The infection of quadrupeds generally by the tuberculous products of man has also been so nearly constant that there is little room for doubt as to the primary identity of the germ in the human and lower animals.

TRANSMISSION OF TUBERCULOSIS FROM MAN TO OX AND FROM OX TO MAN.

The one animal from which man derives the greater part of his meat and milk—the bovine animal—has been by some excluded from this list. The intrinsic value of the animal has prevented its free use for experimental purposes, and a few laboratory experiments, notably those of Kruse and Theobald Smith, have shown that human tubercle may cause a local in place of general tuberculosis in cattle and the opponents of active official measures for the extinction of the disease have seized upon these as alleged proof that the tuberculosis of cattle is in no sense inimical to man. It is incumbent on us to show that the conclusion has been

reached from too restricted premises, and that a wider consideration of the subject would demonstrate that the immediate danger is greater than these contestants suppose, while the remote dangers which come from an adaptation of the bacillus to its new habitat in man are so great that any neglect of this source of infection must be highly reprehensible.

The infection of calves with the tubercle of man was accomplished by Chauveau who, according to Nocard, has shown "that the two maladies under all their forms" (in ox and man) "are equally inoculable upon young bovine animals, and that the consecutive lesions, whether caused by ingestion or intravenous injection, are always identical, whatever may have been the origin of the product inoculated." (Dictionaire de Med. Veter., Vol. 21, p. 476.)

A long list of accidental infections of man from ox tends to corroborate the above.

INOCULATION CASES.

Tscherning attended a veterinarian who cut his finger while making a necropsy of a tuberculous cow. An ulcerating swelling formed which was excised and found to contain tubercle bacilli. The patient recovered without the formation of other tubercles (Nocard).

Pfeiffer of Weimar attended a veterinarian who had been similarly inoculated at the necropsy of a tuberculous cow. The patient, aged 34, had no hereditary taint, and a good constitution. The wound was a deep one, in the left thumb, and healed readily, but six months later there was cutaneous tuberculosis in the cicatrix followed by pulmonary tuberculosis with bacilli in the expectoration, and the subject died two and a half years after the infliction of the wound. At the necropsy there were found tubercular arthritis of the wounded thumb and many vomicæ in the lungs. (Zeitschrift f. Hygiene, Bd. III).

An honored member of this Association was inoculated on the back of the hand in making a postmortem examination of a tuberculous cow, and the sore swelled, ulcerated and refused to heal, and when excised was found to contain tubercle bacilli. He had no ulterior bad consequence.

Martin du Magny has collected a number of cases of cutaneous innoculation of tubercle, some of which were in butchers and teamsters, and Hanot quotes cases in persons who had habitually handled old bones. (Senn, Principles of Surgery.) Riehl and

Paltauf record cases of *tuberculosis verrucosa cutis* in persons accustomed to handle animal products. (Senn). Osler refers to this as the *postmortem wart* (*Verruca necrogenica*) and as common in butchers and tanners. It is also seen in demonstrators of morbid anatomy, and whether derived from, human or bovine carcasses, has a tendency to remain circumscribed. In exceptional cases infection extends to the lymph glands and becomes generalized. (Gerber.)

INGESTION CASES.

Tuberculosis by ingestion is in the nature of things much less clear and definite than is infection by inoculation. With a disease which has a constant tendency to assume a chronic course, the connection of the morbid phenomena with the primary causation factor is likely to be ignored and overlooked. In inoculation cases this is counterbalanced by the occurrence of the morbid action in the cicatrix, which thus serves as an obvious connecting link. But in intestinal infection there is no such ready means of establishing the relation of cause and effect, and the occurrence of manifest intestinal tuberculosis, peritonitis, tabes, hepatitis or splenitis many months and perhaps years after infection is rarely traced to its actual cause. Nevertheless a sufficient number of cases are on record to firmly establish the doctrine of this infection by the products of tuberculous cattle.

Lydtin gives the following case: Dr. Stang of Amorbach was called to a finely developed five year old boy, the son of healthy parents, with no hereditary taint in their ancestors. The boy died a few weeks later with miliary tuberculosis of the lungs, and enormously enlarged, tubercular mesenteric glands. At the necropsy it was learned that the boy had habitually drank the milk of a cow which had been killed shortly before he died and which had shown pulmonary tuberculosis. (Report of Veterinary Congress at Brussels, 1883, p. 288).

Dr. Demme of the Children's Hospital, Berne, records the cases of four infants, the offspring of sound parents, with no hereditary taint of tubercle, which died of intestinal and mesentric tuberculosis, having been fed on the milk of tuberculous cows. Among 2,000 tuberculous infants treated by Dr. Demme in twenty years, these were the only ones in which he could absolutely exclude the possibility of hereditary taint and other causes. (Report of the Hospital as quoted by Nocard.)

Mr. Howe of North Hadley, Mass., lost a son of 20 months old, from abdominal tuberculosis, three months after he had paid a week's visit to his uncle and had been fed the milk of the uncle's cow. The cow was killed soon after and shown to have generalized tuberculosis. The child's sickness and wasting began a few weeks after he returned home. He had previously been strong and healthy, as were and are his parents. Both the grandfathers had died of tuberculosis when over sixty years of age, also two grandaunts and one granduncle. Only one of these had seen the child and then for a few minutes only. A second child born since the death of the first, and raised on sterilized milk, is strong and well.

The four year old son of Col. Beecher of Yonkers (and great grandson of Henry Ward Beecher), died March, 1894, of tubercular meningitis, and the two Alderney cows which supplied him milk were then proved tuberculous by the tuberculin test and postmortem examination. There was no hereditary taint.

The child of Dr. Brown, U. S. A., and now of Ithaca, was similarly cut off by tuberculosis, having lived on the milk of a tuberculous cow.

Oliver records the case of a twenty year old girl, of vigorous health, and good antecedents, who contracted a fatal tubercular meningitis, having drank the milk of cows having tubercular ulcers on their udders and which were found on slaughter to have generalized tuberculosis. (Semaine Medicale, Feb., 1892).

Ernst records the following: A family cow died of chronic pulmonary tuberculosis, from which she had suffered severely for one year. Dr. C. H. Peabody, Providence, found that the tuberculous lungs and heart weighed 43.5 pounds, and extensive tubercles in the mediastinal and mesenteric glands, trachea, tongue, spleen, kidneys, intestines and udder. Three months later the baby sickened and in seven weeks died of tubercular meningitis; two years later a three year old child of the family died of tubercular bronchitis. One year later a boy of five years became weak and puny and died in four years of tuberculosis. The parents were strong and healthy, and one grandparent was alive and well at 68 and another died at 78. (Ernst. Infectiousness of Milk, p. 108.)

A. H. Rose, Littleton, Mass., gives the case of a child which fed for three years on the milk of a tuberculous cow, and died with symptoms of abdominal tuberculosis. (Ernst. Infectiousness of Milk, p. 110.)

Bailey, of Portland, Me., condemned and made necropsy of a tuberculous cow which furnished the sole milk supply for the family, and found that the wife of the owner, though of sound ancestry, was in an advanced state of consumption. (Ernst.)

Gordon of Quincy, Mass., records the case of the ten months child of healthy parents and ancestry, which had fed on the milk of a cow with advanced tuberculosis, and which died after a few weeks of acute tuberculosis. (Ernst.)

Gage, Lowell, Mass., had an infant patient die of tubercular meningitis. The parents were healthy and surroundings good. It had subsisted exclusively on the milk of a cow, and this milk showed tubercle bacilli and infected guineapigs inoculated with it. A second child, fed the same milk, developed similar symptoms. (Ernst. Report Mass. S. Prom. Agric'l, 1871.)

A Scotch family, strong and healthy, had a herd of cows which contracted tuberculosis. Two young daughters brought up on the milk, died of tuberculosis; while the two older brothers, using little or no milk, remained well and hearty. (Tuberculosis. Nat. Vet. Assn., London, 1883.)

Anderson, Iceland, reports the death from tuberculosis of a child of six months, fed on the milk of a cow suffering from tuberculosis of the udder. The mother developed symptoms of consumption after the death of the child. (Hatch Expt. Statn. of Mass. Agric'l College. Bull. No. 3, p. 15).

Huon gives the case of a cow used in nursing calves, which were employed in raising the lymph of variola vaccinæ, and kept strictly by herself and apart from all other cattle. When introduced she had all the appearance of health and gave no reaction when subjected to the tuberculin test. After some time she lost condition and in six months was in an advanced state of emaciation, gave a typical reaction under the tuberculin test and when killed showed extensive (assez grave) tuberculosis. Her care-taker at the vaccine establishment had what was supposed to be chronic bronchitis with profuse expectoration, bnt when he died soon after this was found to be extensive pulmonary tuberculosis.

These cases are adduced as instances of infection that occur casually, and that are almost inexplicable on any other hypothesis than that of direct infection from the cattle. They form exact counterparts to many cases of experimental infection of the smaller animals by the tubercle of man. They tend to show that the bacillus tuberculosis drawn directly from cattle does not always cause a mere local disease, for in two of the inoculation

cases and twenty ingestion cases generalized tuberculosis was the result. How many cases of local tuberculosis must be assumed to have occurred in the same way, but in which the victims either recovered or lapsed into the latent form : And how many cases in which the disease developed tardily, so as to obviate suspicion as to its true source by ingestion, when its evolution had been sufficiently extensive to lead to its recognition.

Shakespeare, Osler, and most prominent physicians, remark on the prevalence of intestinal and mesentric tuberculosis in children as pointing unequivocally to the food supply as the source of infection. Comby in Twentieth Century Practice shows that tuberculosis of the intestines and tabes mesenterica are diseases occuring especially between early and late childhood,—between two and five years. Coming as this does after the child has passed from an exclusive milk diet, it suggests that the disease has been for a time comparatively latent, so that when its generalization calls prompt attention to it, its true primary cause is liable to be overlooked.

The following experimental cases may be added. Two at least show secondary glandular tubercles :

Bollinger made intraperitoneal inoculation of a three months old calf with liquid from a tuberculous human lung, and killed the subject seven months later. Fibroid pediculated tumors, like a pea to a walnut in size, hung from the mesentery and spleen and the mesenteric and retroperitoneal glands were tuberculous. (Munch. med Wochenschr. 1894).

Sidney Martin fed four calves 70 cc. sputum containing a large number of bacilli. Three killed after 4, 8 and 12 weeks respectively had 53, 63, and 13 nodules respectively in the small intestines mostly in Peyer's patches. The fourth killed after 33 weeks showed no lesion.

Two calves receiving at one dose 440 cc. sputum containing a large number of bacilli, were killed after 8 and 19 weeks. The first had tuberculous nodules in the intestine and mesenteric glands; the second showed no lesion. (Report of Royal Commission on Tuberculosis).

Frothingham injected into the peritoneum of two calves, three and thirteen weeks old, a culture of bacilli, isolated one year before from the liver of a child. Slight local nodules only were produced some like spontaneous tubercle, others granulation tissue. Two other calves three weeks and two months old, were injected in the trachea. One had a large local abscess in the neck

with a small number of tubercles (without bacilli) in the lungs and liver. The other showed no lesion.

With the advance of the disease along the lymph channels to the glands, lungs and liver there was a promise of further development under more favorable conditions of life.

TUBERCULOSIS OF MAN AND OX CO-EXTENSIVE.

A strong argument for the intertransmission of tuberculosis between cattle and men is found in the remarkable prevalence of the disease in both genera in some regions, and its absence in others.

In the Scottish Hebrides, Iceland, Newfoundland, and the coasts of Hudson Bay, where cattle are few and the inhabitants live largely on fish, consumption is a rare disease. This is not due to the insusceptibility of the natives, for if they migrate to the localities where tuberculosis abounds they fall easy victims.

In northern Norway, Sweden, Lapland and Finland, where cattle are few and largely replaced by reindeer, there is little tuberculosis though the natives live in close buildings through their long and severe winters.

In most of the Pacific Islands there are no cattle, and the natives are comparatively free from consumption. The Hawaiian Islands, of which this was true until after the introduction of European cattle, have since that date become very subject to the disease.

Australia and Tasmania, which forty years ago were so free from tuberculosis that they became the Mecca for the consumptives of England, have under the advent of the victims of the disease and the universal prevalence of cattle raising, become little better than a hotbed of the affection.

Minnesota and the Dakotas were, thirty years ago, in the early days of their settlement, looked upon as nature's sanitarium for the phthisical, but since the advent of a denser population, many of them tuberculosis refugees, and of domesticated cattle, this reputation has been steadily lost. The Indian population within their borders is now ravaged by tuperculosis to an extent to which it is difficult to find a parallel elsewhere.

In the Kirghiz Steppes the Tartars keep large herds of horses instead of cattle, eating their flesh and drinking their fermented milk, and they are remarkably free from tuberculosis.

In China and Japan the lower classes of the people are rice

eating vegetarians, and in spite of confined and unhygenic homes they rarely suffer from tuberculosis. The Mandarin and aristocratic classes on the other hand are beefeaters and in spite of their more spacious, cleaner and better ventilated houses, and their more abundant and nutritious dietary, they are scourged by tuberculosis.

In Italy the mildness of the climate has long attracted consumptives from the rest of Europe, and it has been and remains a hotbed of consumption for men and cattle alike. The sources of the scourge have been recognized for centuries, and have been restricted by legislation. Flick (Public Health, Vol. XVI) estimates that in Naples the human mortality from tuberculosis was reduced from 10 per 1000 in 1782 to 1.16 per 1000 inhabitants in 1887. Yet in Italy, as in Algiers, the malady remained as a veritable plague." (Perroncito.) In northern Italy where the restriction laws found little countenance the mortality remains 2.2 per 1000 inhabitants, much lower than that of London or Paris, though higher than in Naples.

Holden tells us that tuberculosis is rare in Columbia, Ecuador and the interior of the Argentine Republic, where, as he further alleges, little milk and no butter are used.

The reservations of the North American Indians furnish the most striking examples of the extension of the scourge of tuberculosis. These wards of the nation are supplied with beef under contract, and according to abundant testimony, have been habitually furnished with inferior and often diseased cattle. These they destroy on their arrival and eat large portions raw, especially of the mesentery and internal organs, the usual seats of tuberculosis.

Treon describes as follows, the result of a fresh arrival of beeves at the Crow Creek Agency: "Saturday early in the morning, the cattle are shot down in the corral, and the Indians drag them out, skin and cut them up. I have observed them frequently, when slaughtering, eating the warm liver, tallow and even the entrails, and great quantities of raw beef. In fact much of the beef is dried, pounded up and eaten without cooking. Frequently they eat animals that have died of disease days before, and to my mind, here is a good solution of the trouble. Supposing that only one out of a thousand cattle received, be affected with tuberculosis, * * from the manner of dividing the beef it is possible and probable that 100 persons may become inoculated by a single diseased animal."

Holden gives the mortality for the Indians in different reservations as follows: At Green Bay, Wis., Tulalip, W. T., and Western Shoshone, Nevada, tuberculosis causes 50 per cent. of the total Indian mortality. (Med. Rec. Aug. 13th, 1883).

In considering the case of the Indians we must of course allow for the filth and confinement of the insanitary huts in which they live. But we must not forget that the Hudson Bay Indian and the Esquimaux live in huts just as close, through a still longer winter, and yet are remarkably free from tuberculosis. But then the more northern native tribes are not supplied with the tuberculosis beef.

Now, a critic may say that these are mere broad generalizations, and do not condescend to the mathematical and bacteriological proof which he is inclined to demand. I would reply that such generalization, when broad enough, and clear enough, may be even more certain and less misleading than a series of laboratory experiments. If we find an infection which absolutely respects and avoids a country until given facilities have been furnished for its introduction, and which then spreads without limit,—if we find such infection advancing in parallel lines, in two different genera when once introduced,—if we find that in the absence of one of these genera which furnishes food for the other, that the disease in the latter is confined within comparatively narrow limits,—if we find that with the prevalence of the infection in the food-furnishing genus, the ravages of the disease develop and increase in the food consuming genus,—and if we find this not in a single case only, but as the rule, have we not the best conceivable ground for the conclusion that the infection is propagated from the first named genus to the second? Would the earnest truth seeker be justified in reaching any other conclusion, unless he could be furnished with the most ample proof of a fallacy in the evidence, and a most irrefragible and comprehensive testimony in rebuttal? Before the days of bacteriology and bactriological experiment, we had through such evidence as that just given, arrived at the firmest conviction that nearly all of our contagious diseases were the result of contagion alone, and that, if this factor could be excluded, the disease would be promptly and permanently exterminated. A persistent clamor was maintained against sanitary restrictions, because the contagious diseases were alleged to arise spontaneously, but a survey of the whole field showed that they never attacked a new country save as the result of the introduction of an infecting animal or its product, and that once introduced they spread all the more

virulently because of the more susceptible soil furnished by the previously unaffected races. This was true of small pox, sheep pox, rinderpest, lung plague, foot and mouth disease, glanders, strangles, rabies, Texas fever.

We were just as certain that these diseases were the result of contagion alone, as we are to-day with all the added light from the bacteriological laboratory. We knew that each and all could be *stamped* out by the prevention of contagion, no less than we do to-day. Bacteriology has come to corroborate and not in any degree to weaken this conviction? Far be it from me to depreciate bacteriology. It has thrown a flood of light upon all these affections; it has furnished us means of differentiation, of prevention, and of treatment which we could not otherwise have attained; it has based our sanitary system upon a new order of facts which we formerly suspected but of which we had not the full demonstration; and so far as it has determined the life histories of the pathogenic micro-organisms, it has largely elucidated the essential nature of the morbid processes induced. It has opened to us a new world and is bound to go on laying bare its as yet undiscovered elements of value. We cannot afford to part with bacteriology, and we cannot afford to undervalue or ignore even the smallest of its facts, but these facts must accord with all other facts in nature, and until this co-ordination shall have been accomplished under our eyes, we must not allow the new facts to negative the old and well established ones.

In laboratory work the expert bacteriologist is often under the temptation to estimate the new truths at more than their intrinsic value, and to accord them a wider application than may be finally warranted by intelligent survey of the whole field. Nothing is easier than to adduce examples of this. Pasteur pronounced pigs and chickens insusceptible to anthrax. Like other experienced veterinarians I had no hesitation in at once pronouncing Pasteur wrong,—not in his laboratory experiments, which were quite correct as regards these animals under the conditions of his experiments,—but assuredly so in his general application of his result to all conditions. To-day the whole world recognizes the susceptibility of chickens and swine under given conditions. Koch, on the basis of his laboratory experiments, proclaimed tuberculin to be nature's great cure for tuberculosis. I could never place any trust in its therapeutic utility for the reason that tuberculosis often persists for a long lifetime (the infected system all the time producing and circulating its own tuberculin) without

any satisfactory manifestation of a curative action. The tuberculosis infection is only to a very limited extent self-restrictive, and there are to-day few remaining devotees of the Koch cure. It is now allowed that many cases of incipient and slight tuberculosis recover, but the deadly trend of generalized and advanced cases forbids the assumption that tuberculin is curative. Roux and Chamberland found that 300 times the fatal dose of a culture of bacillus tetani was rendered harmless if it were first mixed with the blood-serum of an immune animal, but their claim of the curative action of this serum was very largely negatived when the serum was used upon men and animals which were already suffering from the tenaic spasms. It proved of more value as a prophylactic before the toxins had already established their action on the nerve cell.

But if bacteriologists need to be careful as to the extent of the claims based on given laboratory experiments, how much more should the layman be guarded as to wholsale deductions from limited observations. We have no complaint to find with the bacteriologist. Every well conceived and carefully conducted experiment is a new source of knowledge, and serves to enforce or qualify the knowledge to which we had previously attained. The scientist himself aims at the promulgation of the new facts without detriment to other truths which have already been well established. Sooner or later he can enlighten us upon the conditions which determine the older truths and those in which the new ones have sway, and the fields of science and sanitary work are commensurately enlarged, and placed upon a broader and more substantial foundation. But when the ambitious layman gets hold of the solitary new result of laboratory work, he is not always deterred from giving it a world wide application, by any knowledge of old-established truths, or scientific sense of the many-sided work carried on in nature's laboratory. In this, more than in most other fields, "a little learning is dangerous," and under the wrong inspiration proceeding from an observation which is given a too wide application, beneficent work is liable to be arrested and grievous evil wrought.

The bacteriology of contagious diseases is as yet in its infancy, and the field of investigation which it opens up is almost illimitable. The laboratory experiment is perfectly trustworthy when we take into account all the conditions in which the result was produced, but when we apply this result generally, without taking into account the infinity of modifying conditions in the microbe,

its recent life history and its environment, we are certain to fall into error sooner or later. An animal that is habitually insusceptible to anthrax or blackquarter becomes strongly susceptible when a little lactic acid is added. And such lactic acid is easily developed in the system by muscular work. Active exertion will, therefore, undo the force of the alleged immunity. The otherwise immune rat becomes very susceptible after he has been made to work at turning a wheel. Similarly the germ which has been rendered harmless to a given genus of animals, by cultivation in a given environment, is still often deadly to the newborn of the same genus.

It is not the accomplished bacteriologist who is to blame in this matter. Dr. Theobald Smith found that the bacilli from human sputum grew more vigorously than the bovine bacillus on dog's serum, that it stained less deeply, that it tended to grow less short and more slender, and that it produced in rabbits only temporary drowsiness and recovery in two weeks. But he gives as freely the opposing indications. One sputum bacillus grew so feebly in dog's serum that its culture was abandoned. He recognizes that fifty per cent. of all bovine cases derived from bovine sources, remain localized. He states that "variations in the dose result in corresponding variations in the length of the disease, in its final termination, and in the extent and distribution of the lesions." He mentions as a possible theory that the long semi-saprophytic life of the sputum bacillus may have lessened its pathogenic power, yet he found in one case that the bacilli from an acutely tuberculous lymph gland was even less pathogenic than that from the sputum. He acknowledges the probability of the transmission of the bovine bacillus to man in these words: "It seems to me that, accepting the clinical evidence at hand, bovine tuberculosis may be transmitted to children when the body is overpowered by large numbers of bacilli as in udder tuberculosis or when certain unknown favorable conditions exist." Again in view of the assumed lessened susceptibility of man to the bovine bacillus, he says, "The occasional entrance of bovine bacilli into the human body might open the way for the introduction of a virus of a higher level, provided opportunity for subsequent transmission be afforded."

These points culled from advanced sheets of his paper which Dr. Smith has kindly sent me, show that his position is not extreme nor objectionable in this matter, and the danger comes

mainly from a misapprehension of his true position by men who come to the question with minds warped by prejudice.

In this connection it is important to note Nocard's latest observations, that the bacillus of human sputum produces lesions in the Guineapig having the character of those caused by the avian bacillus, and that the bouillon cultures of the human bacillus, when enclosed in collodion capsules and subjected to cultures of 3 to 6 months, in the peritoneal cavity of the chicken apparently assume all the qualities of the avian variety. After three such passages through the fowl of 4 to 6 months each, the collodion imprisoned bacillus kills the fowl upon which it is directly inoculated, producing the characteristic lesions of avian tuberculosis.

Without, therefore, in any way detracting from the value of the experiments of Kruse and Smith showing the production of a local tuberculosis in cattle from inoculation with the tubercle of man, or of the results of accidental inoculations in which local lesions only have occurred in man from the implanting of the tubercle of the ox, we cannot safely discard the equally well attested facts of generalized tuberculosis from both forms of infection, and of the habitual prevalence in the same localities over the whole world of tuberculosis in man and ox.

Further experiment is wanted to clear up questions that are yet obscure. What varied conditions beside those already known tend to render the bovine bacillus less adapted to propagation in man? What conditions render the bacillus of man less adapted to the ox? What conditions in the human and bovine systems respectively render them severally specially susceptible to the bacillus from the other genus? We recognize differences which we cannot as yet trace to their intimate causes. We habitually find the greatest difficulty in starting a culture from the living animal on the culture medium usually employed. But when once started there is usually no difficulty in continuing this culture indefinitely in the artificial medium. We cannot yet fully explain the difficulty in the one case and the facility in the other. We wait hopefully for the light which bacteriology and physiological chemistry must one day throw on these questions. Meanwhile we must keep all the known facts in mind, and in our sanitary work guard against the dangers which come from a too exclusive attention to one class of facts.

VOLUNTARY MUSCLE OF CATTLE SELDOM TUBERCULOUS.

Keeping this principle in view, we must recognize that the voluntary muscles of bovine animals are less frequently affected by tubercle than is the case with that of the other domestic animals. They are therefore less liable to convey the infection through ingestion of the flesh than are pigs. A partial truth is assumed to be a general one and it is claimed that beef is never dangerous. But here again the truth lies midway. The muscular tissue of cattle is sometimes the seat of tubercle, though less frequently than in pigs, and the lymph glands that lie among the muscles are quite frequently involved in cattle. It is therefore dangerous and misleading to assume that all raw beef is harmless, and even when sound it is always liable to contamination with hands and knives, when tubercle exists in intermuscular glands or in internal organs.

NONINFECTING MEAT AND MILK MAY CONTAIN THE PYROGENIC TUBERCULIN.

Another point which cannot be ignored is the presence in the blood and milk of tuberculous cattle of the thermogenic product of the bacillus. We know that if this is injected subcutem into the tuberculous man it develops fever, and stimulates the inflammatory and necrogenic processes in the seat of the tubercle. This last process is especially noticeable in lupus. The milk therefore and the meat may be entirely free from the tubercle bacillus, and yet may hasten the generalization of the tuberculosis in the already infected consumer. This is comparable to the constant reinfections established in the tuberculous animal confined in a close building with other consumptives or with an accumulation of its own products. In either case the tendency is to hasten the disease to a fatal issue.

But here again there is a qualifying circumstance. It is a function of the liver to decompose and render harmless the toxins which reach it through the portal vein. Hence, much larger doses of tuberculin can be given by the mouth than by hypodermic injection.

A certain proportion however may escape the sanative action of the liver in connection with hepatic derangement or accelerated circulation, and this is likely to prove a constant stimulus to the advance of the disease.

There is always the further danger that the infecting bacilli from which the tuberculin is being formed, may suddenly become generalized, being washed on with the circulating blood, so traversing all the vascular tissues, colonizing in one or many of the organs, and escaping in the milk or other secretion.

I have hinted at a few of the dangers attending the consumption of meat products from tuberculous animals. The subject of the sanitary care of such animals has not been assigned me. I shall say this, however, that the nature of such sanitary work will be influenced largely by the object. If the aim is the final extinction of the bacillus tuberculosis we cannot be too careful to close all avenues by which it may gain access to the system of man or beast. If, on the other hand, we aspire only to a restriction of its prevalence, it may serve the purpose to destroy only the badly diseased and to condemn only the badly affected products, while the slight, latent and recoverable cases are in a measure ignored.

PAPER PRESENTED AT THE FIFTH ANNUAL MEETING OF THE ASSOCIATION OF VETERINARY FACULTIES.

THE CO-OPERATION OF THE VARIOUS EXAMINING BOARDS AND THE DESIRABILITY OF ESTABLISHING AN INTERSTATE EXAMINING BOARD THE CERTIFICATE OF WHICH WOULD BE ACCEPTED BY THE BOARDS OF ALL STATES.

BY JAMES LAW.

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Only in recent years has there been instituted in any of the United States legislation controlling the practice of medicine or veterinary medicine. Wherever such legislation has been secured it has been at the instance of the practitioners. In assuming credit for the advantages secured by such legislation we must also take whatever blame may be justly charged upon those who inspired the laws in question. That the laws regulating veterinary medicine are beneficial none of us will seek to deny : that there are objectionable things incident to the working of these laws many have felt. That the advantages far exceed the disadvantages we will all agree. We can have no desire to go back to the days of anarchy in medical or veterinary practice.

The question then is mainly what objectionable features is it possible for us to get rid of without sacrificing the indispensable advantages ?

Among the grievances which attach to the working of the State law regulating the practice of veterinary medicine, the following are prominent :

1st. It impairs the sense of unity of the veterinary profession. This is a very serious drawback but it cannot be claimed that the law in question is its only factor of causation. The same estrangement existed before, among the graduates of the different schools, and in enlarging the clan or clique from the school to

the state, the Statute has taken a step in the right direction, and done much to unify the body of practitioners within the limits of the Commonwealth. To this extent therefore the Statute makes for unity as against sectionalism.

2d. It interferes with interstate practice. The prosperous city practitioner, whose clients have largely gone to the seaside, wishes to spend his own vacation at a watering place in another state, and incidentally to continue his practice among his own city clients abroad, and among others. But he is debarred by the statute. To this matter there are two sides. The city practitioner wishes to accommodate his client, and the client prefers his trusted city adviser. He can secure him by visit, for the Statute usually recognizes and authorizes consultations with practitioners from outside the state. This is expensive and disadvantageous but it can be done. On the other hand there is the local practitioner, who serves the watering place during the dull season, but who sees his practice and living absorbed by this well-to-do city practitioner during his natural harvest time. He may well claim that the law which protects his competitor in the wealthy city, should be respected by him in the seaside town. Is it not better that the interloper should be compelled to qualify in the state which he has adopted for his summer residence, than that the law should be nullified and all its beneficial provisions set at naught?

3d. A prospective student cannot choose his school for the advantages it offers him, irrespective of the demands of the state in which he proposes to practice.

The supposed grievance here is more specious than substantial. It is open to the student to secure his education in any school, and afterward to go before the board of examiners of the state in which he proposes to practice, instead of that of the state in which he was educated. He must, of course, see to it that he enters a school which maintains a standard high enough to be recognized and registered, by the examining board of the state of his prospective adoption. We cannot for a moment advocate the acceptance of a certificate of education in a school giving a two years' course, as equivalent to the three years demanded by the statute, we cannot suggest the acceptance of a five months academic year, if the law demands a year of nine months, and we can not recommend that the board of a state which demands a high matriculation examination, shall condone the absence or legal insufficiency of this preliminary examination. The grievance of

the prospective student is therefore by no means so great as it appears and by a little foresight and judicious inquiry he can easily prepare himself for practice in the state of his choice. There is really nothing in his supposed claim or grievance that deserves a moment's consideration apart from the desire to be allowed to practice in a given state, on the basis of preparatory work and accomplishments below those demanded by the laws of that state, and enforced on the other practitioners in that state.

Such a claim (that an alien should be admitted on a lower requirement than the citizen is so utterly preposterous that to simply state it is to put it out of court.

4th. The most serious grievance and the only tenable one is that of the new graduate who has not decided upon a location in which to practice but who receives encouragement to settle in another state than the one in which he has received his degree and his license to practice. With him may be classed the old practitioner who wishes for any reason to move from one state into another, and who does not care at his age to face an examination. Here there is some appearance of hardship but after all it is more in seeming than in reality. A particular state has enacted in its statutes that no one shall be henceforth licensed to practice within her borders who is not possessed of certain definite qualifications. Our aggrieved student, if he had any expectation or aspiration to practice in that state should have entered a school in which he would have been furnished with these qualifications. In seeking his education through an easier channel he deliberately excluded himself from the right to practice in that state. Who is to blame? And who should be called upon to correct the fault? If the state must admit him on qualifications that are below the standard required by its statute, it introduces an incomparably greater evil. It does wrong to every law-abiding veterinarian in the state who entered on practice by complying with the prescribed standard. It offers a premium to the under educated alien who is not law-abiding, at the expense of the educated citizen who is law-abiding. It fosters the low class school provided it is outside its own limits, at the expense of the school of a higher class within its limits. It certifies to the stock owners of the commonwealth that they can trust their live stock, as safely in the hands of a man educated in a neighboring state to a low standard, as in those of the man educated at home up to the legal standard. If the state is to admit to practice the under educated alien, it should begin by cutting down the require-

ments demanded of its citizens in its home schools. In a case like this every step taken by the state for the relief of the alien, who is not up to the state requirement, is a lowering of the standard of veterinary education. It is a direct infringement of the law, and this in favor of a degradation of the profession. This should not be countenanced by such a body as this.

Even in the case of the old practitioner it is very questionable whether the law of higher requirement can be set aside with safety. In securing the various state laws regulating veterinary practice, it became necessary to admit to license to practice all practitioners of several years' standing, even those without a degree and in too many cases without education, and these men are entitled to all the privileges of the educated veterinarian within the commonwealth. But an adjacent state is under no such obligation, and if this uneducated practitioner desires to move into such other state, it would be poor policy to certify to his qualifications by granting a license, unless he shall have complied with the requirements of the state of his adoption.

The laws regulating veterinary practice usually contain a clause by which a definite number of years of reputable practice may be accepted as the equivalent of a college course, or even of the matriculation requirements. But they should not, and our New York law does not, allow that this shall stand in place of an examination for license. To secure a great future good a state may wisely endorse for the time an old established and temporary wrong which has established a vested right.

But no such consideration should warrant the uncalled for introduction of such wrong into a neighboring commonwealth.

If the state imposes such a barrier against the entrance of the nongraduate practitioner from the neighboring state, is it not equally called upon to admit the graduate practitioner only under the required test? It may well be argued that the experienced graduate practitioner who has not kept himself in such relation to the literature of his profession as to enable him to pass easily such an examination as is given for license is not a desirable acquisition. It may also be claimed that the admission of the old practitioner without test, into a state which subjects all new graduates to a very searching test and a high standard, may prove a bid for the introduction of mediocrity or inefficiency, which the state thereby endorses and commends to its stock owners. The old practitioner who cannot hold his own against the competitor fresh from even the poorest schools, may sell out and moving into

a state in which the standard is higher, may start with all the false plumage which the state endorsement can give him. I do not wish to commit myself irrevocably on this question of the graduate practitioner, but with my present light I am quite satisfied with the New York state law which requires examination as a prerequisite to license.

Having thus cleared the field somewhat of questions involved we may enquire how far can the different state licensing authorities reciprocate by accepting the results of the examinations made of each other?

In facing this question, we must conclude what is just and proper, or what is admissable, rather than what is at present legal. Yet there are certain leading constitutional requirements which cannot be overstepped. We cannot secure a national examining nor licensing board which can have any authority in the individual state. We can have no conglomerate private board (composed of representatives of the different states) which can exercise any authority within their several boundaries.

Congress cannot impose such a board upon the individual state for the administration of its internal government. It is difficult to see how such an examining or licensing body can be of any value in conferring an authoritative degree or license which may have the force of law in the different states.

If it were possible to have each member of such examining or licensing body appointed in each state independently as a state official, it would I believe be proper to recognize their action as the action of each state and as binding within its limits.

To give this arrangement the color of legitimacy the candidates for places on the board would have to be elected by the great body of veterinarians throughout the land. It would then be representative and carry a moral weight which it could not attain to if nominated or created by a small select body like the United States Veterinary Medical Association from which the expense of active membership excludes the great body of practicing veterinarians.

An arrangement of this kind would at once develop that organic unity of the whole profession in the United States, which has been one of its greatest desiderata up to the present. It would beget an *esprit de corps* and a sense of individual responsibility and power which do much to elevate, reform and ennoble the profession.

Among drawbacks to such a proposal may be named the neces-

sity that the board in question should sit in each state for the examination of candidates, for although their decisions made in one state might be considered valid in another, yet it is manifestly impracticable to have the candidates for graduation assemble from all the states, at one grand rendezvous. The men of California and Maine could not be compelled to attend in Kansas City, nor the New York and Philadelphia men in San Francisco. There would be resulting difficulties at every step. The examining board would be so frequently on the move from one part of the country to the other that they could not well maintain home practice, and their remuneration and the expenses of their frequent long journeys could not be met by examination fees, but must be provided for in some other way. In short with all its advantages, this plan of a national examining board is far from being an ideal one, and reduced to practice would prove unwieldy, awkward and virtually impracticable.

It entails besides the adoption of the very provision the absence of which stands in the way of the mutual acceptance in each state of the license given by every other state : The adoption, namely, of an uniform standard of veterinary education for all states alike. This is a *sine qua non* to any acceptable or successful system and, if once this is adopted, we will do well to abandon any unnecessary machinery and have the licensing boards of the different states accept as equivalents the examinations made by the official boards of sister states.

THE ONLY POSSIBLE UNIFORM REQUIREMENT.

This brings us back to the question : What standard of education can be adopted by all? The only standard which can be universally accepted is the highest that is demanded by statute in any one state. No state can righteously admit to practice, a man from a school outside its borders at a lower standard than it demands of the graduate of the school within its domain. Without further argument, therefore, any accepted uniform standard must be the highest standard maintained by any one state. Deny this and you deny the possibility of obtaining any national board and any standard or license that will be universally acceptable.

By the adoption of a lower standard you would not only set a limit to all future advancement of the profession, but you would demand a retreat from the best standard which is already in force.

As representatives of the veterinary teachers of America we can not give our voices for a compulsory lowering of the standard

of any state. If all states and schools are prepared to elevate their requirements to the level of the highest now in force, the adoption of reciprocity as regards the examinations and licenses of different states is simple and just. But if all are not prepared to rise to the highest existing standard, such general reciprocity becomes impossible, and an alternative course must be devised and adopted.

RECIPROCITY OF STATES HAVING THE SAME STANDARD.

I can see only one satisfactory way of reaching such an alternative : namely for those states which have the same or equivalent standards to adopt a system of reciprocity among themselves to the exclusion of all those which maintain a lower standard. We might thus have two, three or four standards for as many different groups of states. The licenses to practice issued by standard No. 1. (the highest) would then be accepted all over the United States, but no licenses under standards 2, 3 or 4 would render the holder eligible to practice in the states which held to the standard No. 1.

The licenses to practice issued according to standard No. 2 (the second grade) would admit to practice in all states adhering to standard No. 2, and to 3 and 4 as well, but not to the states maintaining standard No. 1, and so on through the different grades of 3 and 4.

This principle is simple, and equitable ; it requires no machinery and no expense that is not already provided for in every state which maintains a legal standard at all ; it should and would be acceptable to every fair minded man in the profession and out of it.

The student can find no fault, for just as he knows that he can practice nowhere without a degree, he will also know that to practice in a given state he must have a degree of the grade which that state demands, and he must enter a school which will raise him to that grade. The practitioner can find no fault for not only will he have the right to move into a state which maintains the standard demanded in his own, or into any one satisfied with a lower standard, but he can also enter one which maintains higher grade by passing the examination imposed.

The schools should be placated since those which prefer the shorter and cheaper course will cater for such students as prefer to confine their practice to the states having the lower standard,

while those that give the longer and more thorough course will cater for those who aspire to practice in states that maintain the higher standard, or who wish to secure the right to practice in any state which offers the best prospect. Each school will reap the advantage of the special standard it may adopt: the shorter and less thorough one attracting the larger numbers, who cannot afford the means nor time to pursue the more extended course, while the school with a more extended and elaborate curriculum, will look for those only who can afford this, and who hope to secure the prospective privileges and advantages.

Everyone will know definitely where he stands, and there will be no ground for the current complaint of the short course men that they are not admitted to the privileges secured by the long course, and no excuse for exclusion by the licensing board of one state of the licensees of a neighboring state which maintains higher requirements, until the second state will accept the licenses granted by the first on a lower requirement.

CONCLUSION.

In conclusion, I can see no way of reaching a satisfactory system of reciprocity of state examinations and licenses through the cumbrous machinery of a national board of examiners. The satisfactory operation of such a board can only be secured by raising the requirements of all states to the highest existing standard. If this uniform elevation of the standard to the highest present requirement can be secured the national examining board will be rendered unnecessary as the different state licenses should thus become interchangeable. So long as a certain number of states are unprepared to adopt the highest existing requirements, the only alternative is to group the states according to their standards, and let there be reciprocity of license among the states of any given group, and acceptance of their licenses by all states holding to a lower requirement.

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Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

VETERINARY DIVISION.

Tuberculosis in Cattle and its Control.

NEW YORK STATE VETERINARY COLLEGE.

By JAMES LAW.

PUBLISHED BY THE UNIVERSITY,
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TUBERCULOSIS IN CATTLE AND ITS CONTROL.

BY JAMES LAW.

PREVALENCE AND RELATIVE IMPORTANCE.

Our interest in tuberculosis centers in two leading questions: First, its prevalence in man; and second its diffusion among domestic animals which furnish food for man. If we consider the disease in man only, we must view it first in its sanitary relations, and, as regards the measures available for its restriction, in its moral bearings. If we consider the disease in the domestic animals we enter largely into its economic bearing, but in view of the use of these animals and their products for human food the sanitary and moral questions must also be admitted.

MAN: GENERAL MORTALITY.

In a man it is admitted that, in civilized countries, where data can be secured, one death in seven is due to tuberculosis. Allowing 15 deaths per 1,000 on our 70,000,000 this would furnish 150,000 deaths per annum from tuberculosis in the United States. Dr. Osler, of Johns Hopkins University, says this is a very low estimate. A war which should leave 150,000 dead on the battlefield every year would rouse the nation to put a speedy end to the destruction. The mortality from tuberculosis exceeds the combined deaths from war, famine, plague, cholera, yellow fever and smallpox. Yet we have those among us who deprecate any intelligent measure for the extinction or restriction of this source of such a constant mortality and loss.

The mortality from tuberculosis in man rises far above this ratio when conditions are favorable to its propagation. In some large cities (Vienna) the ratio of deaths from tuberculosis is more than double what it is for the entire country. In the Marquesas

Islands it rises to 33 per cent of the total mortality, and in some of our Indian reservations to 50 per cent. (Treon, Holden.)

TUBERCULOSIS IN ANIMALS.

Tuberculosis is rare in cold blooded animals, but Sibley has seen it in *reptiles* in a state of confinement.

In *birds* it is common and destructive, but not readily transferred from bird to mammal. The bacillus of the bird is usually a modified form, which prefers a special avian habitation.

Wild mammals in confinement suffer excessively. In menageries apes die almost exclusively from tuberculosis, while kangaroos, deer, elk, gazelle, antilope aud lions are common victims. The rats, mice and other vermin about our houses and barns also contract the disease and all must be recognized as possible bearers.

Cattle suffer more than any other domesticated animal, and tuberculous cattle are especially to be dreaded seeing that they furnish so much food for consumption by man. The Danish herds which were said to be sound until after the importation of Schleswig and Shorthorn cattle in 1840 and 1850 are now generally infected, 17 per cent of the cattle slaughtered showing tuberculosis, while over 60 per cent of the dairy herds showed the disease under the tuberculin test. Statistics from German abattoirs give, for cows 6.9 per cent tuberculosis, for oxen 3.6 per cent, for bulls 2.6 per cent, and for yearlings and calves 1 per cent. In Berlin abattoirs 15 per cent proved tuberculous. By the tuberculin test of New York State herds (2.417 head) in 1894 16.75 per cent proved tuberculous. This is undoubtedly too high an estimate for the entire cattle of the State, as the herds were examined because the owners suspected them and requested examination by the tuberculosis commission. Yet it cannot be said that this represents the extreme of infection as I have found one herd of 60 and another of 200 in country districts of this state tuberculous without exception. These represented cases in which no precaution had been taken to prevent contagion.

Swine are also very subject to tuberculosis, especially through the consumption of the uncooked offal of slaughter houses and of the milk of tuberculous cattle.

Rats and mice readily contract the disease from feeding in the managers of tuberculous cattle and swine, and in their turn carry the disease from manger to manger and from barn to barn.

Rabbits, Guinea pigs and goats when left at large do not readily contract the disease but are very susceptible to the infection when it is conveyed to them experimentally.

Horses, asses, dogs, cats and sheep do not readily contract the disease under ordinary circumstances, but this cannot be attributed mainly to insusceptibility since one and all take it easily when inoculated. The habitual immunity is therefore largely due to the absence of opportunity for infection, and in some degree also to the outdoor life and the well developed state of the muscular system and blood. For the house dog and cat infection has often come from eating scraps from the plate of tuberculous people and in some instances from licking up the expectoration. At Alfort only 40 dogs were found tuberculous in 9,000 *post mortem* examinations.

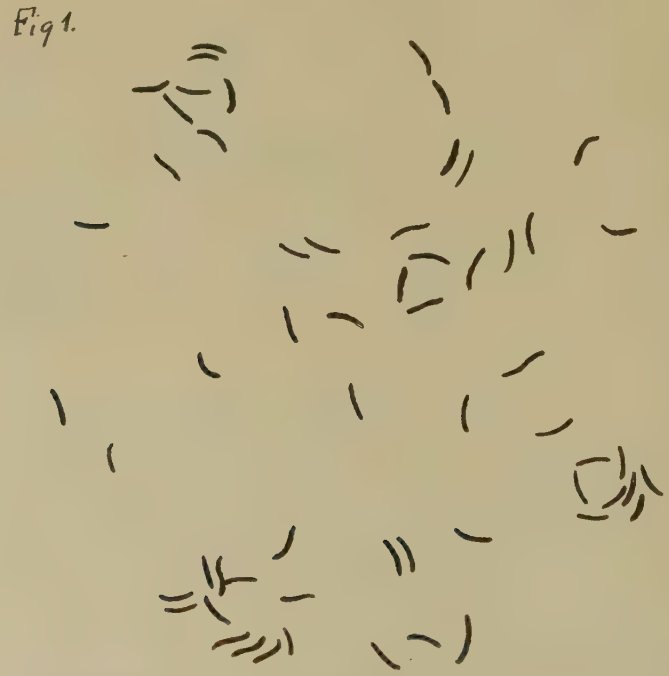
TUBERCULOSIS CONTAGIOUS.

That this disease is contagious was recognized by many of the medical lights of the 16th to the 18th centuries. Morgagni, Lænnec, Cullen, Wickman, Valsalvi and Sarconi, and for animals, Ruhling, Krunitz, Fromage, Huzard and others leave evidence corroborating this belief. The civil and ecclesiastical laws joined in forbidding the use of the meat from tuberculous animals, and in prescribing the destruction or disinfection of articles that might have become infected from tuberculous persons.

This was placed on a solid basis by the many successful experimental inoculations of the disease by Villemin in 1865 and by his numerous followers, who conveyed the disease by feeding tuberculous matter, and by causing the animals to inhale tuberculous liquid in the form of spray. Finnally, Robert Koch, of Berlin, completed the demonstration, placing the keystone in the great arch of evidence, by the discovery of the tubercle bacillus, which he invariably found in the diseased tissues and in no others, and which he cultivated in pure culture in glycerine

bouillon, and inoculated successfully upon a large number of animals.

Since that time (1882) his position has been corroborated by all competent observers, and there is no truth in medicine more thoroughly established to-day than the essential connection be-



1.—*A drawing from a preparation of tubercle bacilli magnified about 1000 diameters.*

tween tuberculosis and the tubercle bacillus. This bacillus has been so often conveyed with destructive effect from man to the smaller mammals, and even to cattle, that the essential identity of human and bovine tuberculosis must be accepted. The statement requires the qualification that the bacillus, like other pathogenic germs, adapts itself to the conditions of the medium on which it grows, and therefore, in the first place to the particular genus of animals in which it has been living for some time, and is therefore often less ready to grow in one of another kind

than in one of the same genus. The most extreme example of this is found in the bacillus of the bird which can only with difficulty be made to grow in the system of the mammal.

But even in the mammal the virulence of the bacillus for other mammals of a different genus or species may be very varied.

Theobald Smith obtained, from a pet bear that had been owned by a tuberculous master, bacilli which seemed to have no ill effect when inoculated on cattle, and had a somewhat reduced virulence for Guinea pigs. Kruse found bacilli from human sputum, and others from the lungs of cattle which produced only local tubercle in Guinea pigs.

Clinical observations show that the same is true as between different individuals of the same genus and species, and hence we find instances of tuberculosis in given herds, which continue for a number of years with few cases showing generalized and fatal results; and other instances of herds in which the disease makes rapid progress, soon affecting all or nearly all of the animals, and proving fatal to a number in rapid succession.

This modification of the germ by its surroundings is again well shown in the common experience that it is usually difficult to start (on artificial media in flasks) the growth of tubercle bacilli taken direct from the animal, but when once started and accustomed to grow on such new materials, it may be started again in fresh culture with great certainty.

In stating, therefore, that the one and only cause of tuberculosis is the tubercle bacillus, it is not to be understood that it is affirmed that that bacillus is at all times, under all circumstances and to all animals, equally virulent and destructive. If the conditions are favorable it will prove very deadly, while, if unfavorable, it may linger for a time without producing much obvious effect on the general health. Its presence, however, in any herd is a constant menace to all members of the herd, to the attendants, to the consumers of the meat and dairy products of the herd, and to other herds into which members of this herd may be sent. It is also worthy of note, that the power of adaptation of the germ to its surroundings, introduces this further element of danger that, as it becomes adapted to its life in a given animal or in the different members of a closely bred

herd, in the natural course of events it must become better and better adapted to survival in that particular animal and breed, and hence increasingly dangerous to all of its members. This is one reason why tuberculosis is so liable to become intensified in special herds of thoroughbred stock, and why common cattle with a varied ancestry will sometimes seem to offer a longer resistance to the affection. It may also explain the fact that with ample exposure the disease does not always pass from men to cattle and from cattle to man.

Yet it would be folly to argue from such data that the disease, when present in an occult form in a herd, may be safely ignored, and that the products of such herd may be safely consumed by man. The very adaptability of the tubercle bacillus sufficiently contradicts this conclusion. The mere continuous presence of the bacillus in a given system, human or brute, is the means of securing a better and still better adaptation to that form of life, and a greater and still greater measure of potency, so that when the health of the host or exposed animal is in any way reduced it may at once become deadly and far reaching in its evil effects.

CHANNELS OF INFECTION.

Among the channels of infection the following may be noted:

1. *Inhalation by the breath.* This is perhaps the most common method of infection and is usually followed by tuberculosis of the throat, lungs, and lymphatic glands of the chest. Expectorations and other infecting discharges are dried up and raised in dust so that they can be easily inhaled. Cases of this kind have been observed in buildings in which a victim of advanced tuberculosis was employed. The other employes fell victims, one after another, to the infection. They are quite common in infected barns, in which the virulent dust carried in the air is inhaled by a number of animals. Experimentally it has been shown by mixing virulent matters in liquids, atomizing them and causing animals to inhale the spray. In the hands of Villemin, Koch, Thaon and Tappeiner this almost infallibly produced tuberculosis of the lungs. In man too, many infections and reinfections have been traced to the dust from the soiled handkerchiefs. On the other hand it must be distinctly understood that

the breath of the tuberculous is not in itself infecting, and if care is taken to prevent the diffusion of the infested solids and liquids and their distribution in dust, the presence of a tuberculous individual is not a threat to others adjacent.

2. *Iufection through food and drink.* A whole host of experimenters have conveyed the disease by mixing infecting pus or an emulsion of the tubercle with ordinary food. The same has been often accomplished with milk from the infected animal even to cases in which the mammary glands seemed to be perfectly sound. The danger of course is enhanced in ratio with the number of bacilli present, so that one diseased cow in a large herd leads to little infection if the milk of the whole herd is mixed. On the other hand such admixture of the virulent milk with the wholesome contaminates the whole to some extent, and inoculation with such mixed milk will often convey the disease when the animals drinking it do not seem to be injured by it.

The infection usually takes place through the tonsils, pharynx or bowels. In ruminating animals it may attack the first three stomachs the contents of which are neutral or nearly so, but it rarely attacks the true digesting stomach the secretion of which is strongly acid. The bacillus is liable to perish or to be so distributed by the acid in passing through the stomach that it is largely shorn of its danger. Among the conditions that favor its safe passage through the stomach may be named indigestion and a too rapid progress of the undigested food through the stomach, a condition which is especially common in young animals: overloading of stomach: the ingestion of an excess of cold water just after a meal, thereby rousing excessive vermicular movement of the stomach and premature expulson of its undigested contents; and the enclosure of the infected matter in a mass of fat which the gastric secretions are impotent to digest or emulsionize.

3. *Inoculation in wounds.* This is a common channel of infection in man. Accidental inoculations—in making post mortem examinations have been often noticed since the case of Lænnec; or in making artificial cultures in the laboratory; or in washing the clothes of tuberculous persons; or in dressing the tuberculous sores; or in making operations, notably that of circum-

cision; or in inserting earrings formerly used by tuberculous persons; or in inhaling the infecting dust through a nose excoriated by a catarrh; or in handling infected carcasses in the butcher's shops; or finally through mouth or throat abrasions caused by hard indigestible materials.

4. *Through the mammary glands.* This gland is especially subject to wounds by the horns and to sores and abrasions in connection with milking which form entrance-channels for the bacilli present in the dust of the barn. The opening of the teat is also a door of entry through which the germ may invade the milk ducts and glandular tissues. It is not to be forgotten, however, that the milk gland is especiably liable to become infected through the blood which is sent in such enormous quantities through its tissues, and is liable to implant any bacilli which may have entered the blood stream. The gland is, therefore, especially liable to infection from without and within and once infected is a source of the greatest danger to the milk consumer.

5. *Through sexual congress.* In cows the generative organs are often the seat of tuberculosis inducing nymphomania or sterility, and the disease has been repeatedly produced experimentally by smearing the infecting matter on the penis or introducing it into the vagina. The bacillus has even been found in the semen of an infected male so that transmission by this channel to the female can be easily understood. All this has a very direct bearing upon the question of the propriety of using the same sire on the tuberculous and sound, and of the admission of females from tuberculous herds to be served by the sires in sound ones.

6. *Through heredity.* Hereditary transmission of tuberculosis has long been recognized, and until recently accorded a rôle much more important than its infrequency would warrant. Various conditions militate against its occurrence; the fœtus is essentially a carnivorous animal, living on the secretions of the dam and not on the direct products of the vegetable kingdom. It has, therefore, that measure of resistance which inheres in the flesh feeding as compared with the vegetable feeding animal. It may be infected through the semen of the sire, but the rule appears to be that the ovum thus early affected rarely

attains to its full intrauterine development. It may be affected from the tuberculous generative organs of the dam, but here again abortion is liable to cut short the existence of the embryo. In spite of all drawbacks a certain small proportion of the offspring are affected with tuberculosis and come to the full period of gestation. In case of infection from the dam the disease is especially liable to attack the liver in which so much of the placental blood at once circulates. Cases of the kind are recorded by Malvox, Brouwier, Bang, Lungwitz, Bärlund and Rieck, and in the tuberculous herd of a large public institution in New York several instances were noted.

The infrequency of such an occurrence may, however, be inferred from the fact that in 800,000 calves slaughtered only 7 were found tuberculous.

INDESTRUCTIBILITY OF THE BACILLUS TUBERCULOSIS.

The bacillus may be said to be capable of surviving drying, the action of water, and putrefaction. It is destroyed by heat (162° to 212° F), sunlight, or in one month by heavy salting.

CONDITIONS WHICH FAVOR TUBERCULOSIS.

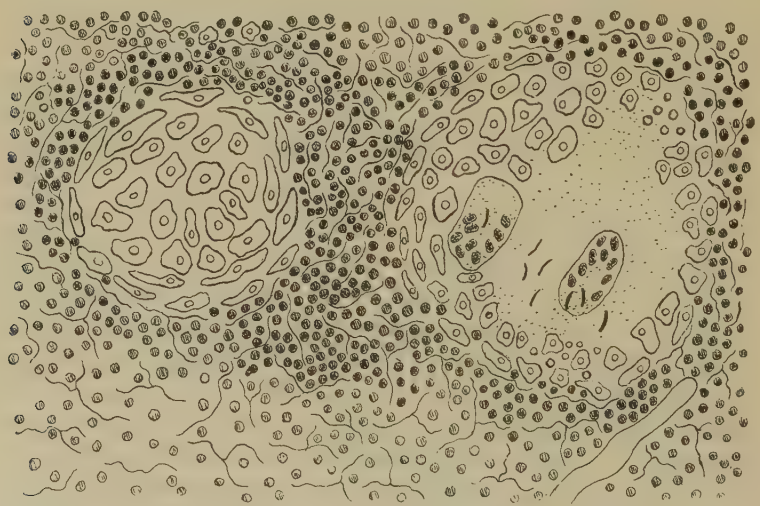
A personal predisposition to tuberculosis is a prime requisite, and this is rendered hereditary by close and inbreeding and breeding in line. Hence the great danger of tuberculosis among inproved breeds. Again whatever undermines the health or stamina, such as breeding before maturity, breeding and heavy milking, breeding the old and debilitated, an insufficient ration, an ill-balanced ration which stimulates unduly the secretion of milk, ill health, local inflammations in the air passages, lack of ventilation, constant stabling in dark, damp, undrained stables and wet soils, greatly favor the reception of the bacillus. The impure air, lack of sunshine and accumulation of the germs in large cities make a destructive combination. In France, cities of under 10,000 lose 1.8 per cent yearly from pulmonary tuberculosis, while Paris with its 2,000,000 loses 4.9 per cent. In Vienna hospitals 85 per cent of the bodies show tubercular lesions. In

Bavarian Monasteries 50 per cent of the young postulants die in a few years tuberculous. In New York City charity hospital 30 per cent of all deaths show tubercle lesions. Where country cows are tuberculous to from 1 to 5 per cent, city cows are so from 9 to 20 per cent and upward. On the contrary our prairie and plains fat cattle show but 0.02 per cent tuberculous. In the Southern States with an unbroken outdoor life country cattle are nearly all sound, whereas in large cities like New Orleans they are largely tuberculous.

APPEARANCE AND FORMATION OF TUBERCLE.

The term tubercle is drawn from the rounded nodular form of the diseased process. The bacillus lodged in the tissue multiplies

Fig. 2.



2.—*A drawing of a section of a very young tubercle in spleen.* (*Thoma*).

and causes congestion and extraordinary growth of cells. The affected points may be at first no larger than millet seed, but these may increase and run together so as to form conglomerate masses of one, six or nine inches in diameter. As the cell growth increases, the central ones degenerate, die, and form a yellowish

white, soft, cheesy mass (caseation) and these numerous cheesy centres become very characteristic of the disease. Sometimes the tubercle develops into a hard fibrous mass the centre of which may still caseate. In other cases it becomes calcareous or gritty a condition which is usually associated with caseation. Sometimes the caseated mass softens into a whitish cream-like fluid.

COMMON SEATS AND SYMPTOMS OF TUBERCLE IN CATTLE.

Tuberculosis of the lungs may be chronic or acute. The chronic cases may last indefinitely with no other symptom than an occasional cough on leaving the hot stable for cool air, when suddenly raised in the stall, when made to run, or when drinking cold water or eating dusty food. The cough is usually small, dry, wheezing and repeated several times in succession. The general health may seem to be good, the subject may be fat or a heavy milker. To the trained ear, wheezing, crackling, or other unnatural sounds may be heard in the lungs or they may fail of detection. There may be a discharge from the nose, which when stained and placed under the microscope may show bacilli, but by cleansing the nose with the tongue the animal may make this test practically impossible.

Acute tuberculosis of the lungs on the other hand may prove fatal in a month. It is attended with rapid loss of condition, staring coat, elevated temperature, hurried breathing, frequent weak, husky or rattling cough, heavy, mawkish breath, and nasal discharge containing gritty particles or opaque yellowish masses. Pinching of the back, breastbone or spaces between the ribs, or striking the ribs with the knuckles may cause wincing, groaning or cough, and auscultation over the ribs may detect sounds of friction, wheezing, creaking, crepitation, rattling, or blowing, etc. Percussion over the chest detects areas of lack of resonance corresponding to the seats of tubercle or pulmonary infiltration. A significant feature is that these areas of flatness are distributed over the lungs, and not confined to one spot as is common in pneumonia. Appetite and rumination fail, bloating occurs after meals, the bowls may become irregular, and

3 —*Drawing of tuberculous spleen in pig showing tubercles 2-3 the natural size.*

indications of tuberculosis in the throat, or superficial lymph glands may appear.

Tuberculosis of the stomach and bowels is common in young animals living on milk but is not infrequent in the mature animal as well. It may come from infected milk, or from the swallowing of the diseased products coming from tuberculous throat or lungs. In calves there may be noted indigestion, fœtid diarrhœa, bloating, and finally cough and expectoration or swelling of the superficial lymph glands. In older cattle there may be irregular appetite and rumination, bloating after meals, costiveness, alternating with diarrhœa, colics, and marked emaciation. The oiled hand introduced into the rectum may detect the enlarged mesenteric glands, which must be carefully distinguished from hardened fœces in the bowels, from the ovaries, from masses of fat, and from the cotyledons of the womb.

Tuberculosis of the womb and ovaries may depend on infection by the bull, or may be a complication of intestinal and peritoneal tuberculosis. It is usually marked by sterility, abortion, by frequency and intensity of œstrum, and by marked emaciation. Sometimes there is a white vaginal discharge.

Tuberculosis of the liver, spleen and pancreas is also a common accompaniment of infection of the bowel or abdominal cavity. The liver and spleen are especially liable to suffer from being on the line of circulation of the portal vein which brings blood from all the

other abdominal digestive organs. The lymph glands on the posterior aspect of the liver are especially liable to suffer. With liver-tuberculosis there may be jaundice accompanied by other symptoms of digestive trouble, but as in the affection of the spleen and pancreas there is oftentimes only an indefinite ill health.

Tuberculosis of the kidneys may be attended by extra tenderness of the loins to pinching and by frequent passage of urine, which may be discolored by blood or pus. The urine is likely to contain microscopic cylindroid casts and when stained these may show tubercle bacilli.

Tuberculosis of the udder is usually manifested by a circumscribed or general swelling of one or more quarters, without at first special tenderness, and this gradually extends to the whole gland. The milk may be watery, grumous, or even bloody and the lymph glands in front of the udder and behind are enlarged and hardened. The tuberculous nature of the lesions can only be certainly determined by the discovery of the tubercle bacillus in the milk, by the successful inoculation of the milk on a small animal, or by the tuberculin test.

Tuberculosis of the throat and pharyngeal lymph glands is one of the most common forms of tuberculosis in cattle. It causes a wheezing breathing, glairy discharge from the nose or mouth, difficulty in swallowing and a loose gurgling cough. The diseased glands may be felt as soft swellings around the throat, or as shrunken hard nodular bodies, or as masses fluctuating by reason of their liquid contents. When the disease extends to the interior of the larynx it causes a persistent, paroxysmal, husky cough.

The lymph glands inside the lower jaw or those near the root of the ear may swell up, soften and discharge a cheesy or thick creamy fluid containing the bacillus.

The lymph glands inside the chest—bronchial mediastinal, etc.,—are especially liable to suffer, as they receive the infected lymph which comes from the diseased lungs. These often suffer when no lung disease can be found, the bacilli having passed through the lung without forming any primary lesion in that organ, or those that have been formed having healed. These are often attended by no distinctive symptoms, and require the tuberculin test.

Lymph glands in front of the middle of the shoulder blade may be suspected if of unequal size and form on the two sides, if hard and nodular, or if soft and fluctuating. They rarely caseate and burst.

Other lymph glands that may be similarly affected, and that are superficial enough to be felt, are the *glands at the entrance of the chest* in front of the two first ribs, the *glands on the flank* above and in front of the stifle, and, in the young, the *glands situated high up in the groin.*

Tuberculosis of the bones and joints is seen in young growing animals, affecting especially the large joints of the limbs, the elbow and knee, the stifle and hock, but also at times the bones and joints of the digits. The ends of the bones become enlarged and tender and the joints overdistended, tense and elastic. The lameness may be extreme.

PROPORTION OF OCCULT CASES.

In herds which have the disease in the most intense form, by reason of long standing, indoor life, and repeated reinfection nearly all may be detected by the objective symptoms, but in such herds nearly every animal is diseased. In ordinary herds, where the disease is less intense, at least two-thirds of the diseased animals would escape under such an examination. In one herd of 70 head in which the tuberculin test condemned 24 head (being 50 per cent of the mature animals) I left the examination after slaughter to the veterinarian of the A. J. C. C. who was at the time skeptical as to the value of the tuberculin test. He wrote me afterward of his surprise at finding every one of the 24 condemned animals tuberculous, when not one of them had shown symptoms by which he could recognize the disease in life. This is no exceptional case, and may be advanced rather as a typical example of the ordinary infected country herd.

It is manifest that if we aim at speedily and certainly clearing a herd of tuberculosis we must have some better method of diagnosing the disease than the best physical examination. Attempts have been made to discover the bacillus in the expectoration, milk or nodular lymph glands, but this requires prolonged care-

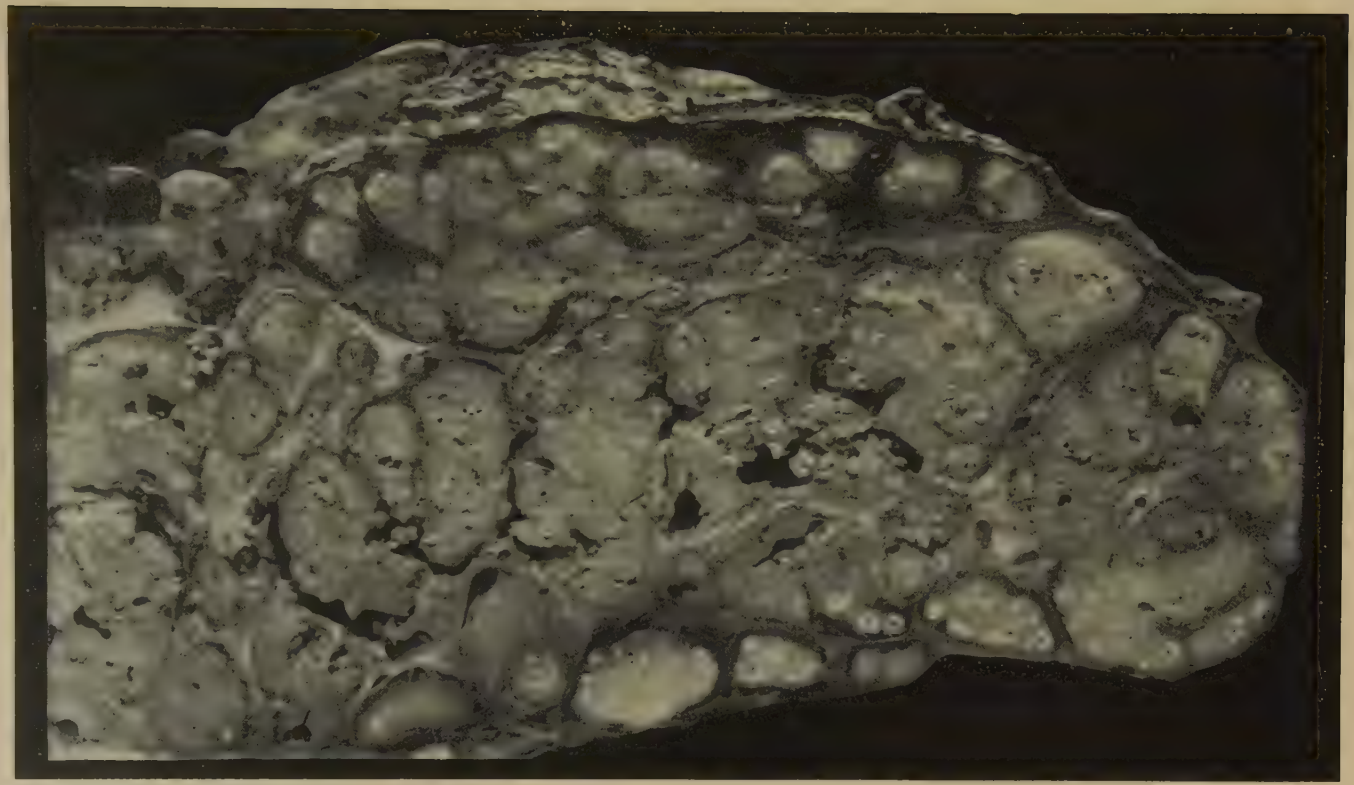


PLATE I.—*Photograph of a section from anterior lobe of a tuberculous lung of a cow, showing rounded tubercular infiltration and calcified centres.*

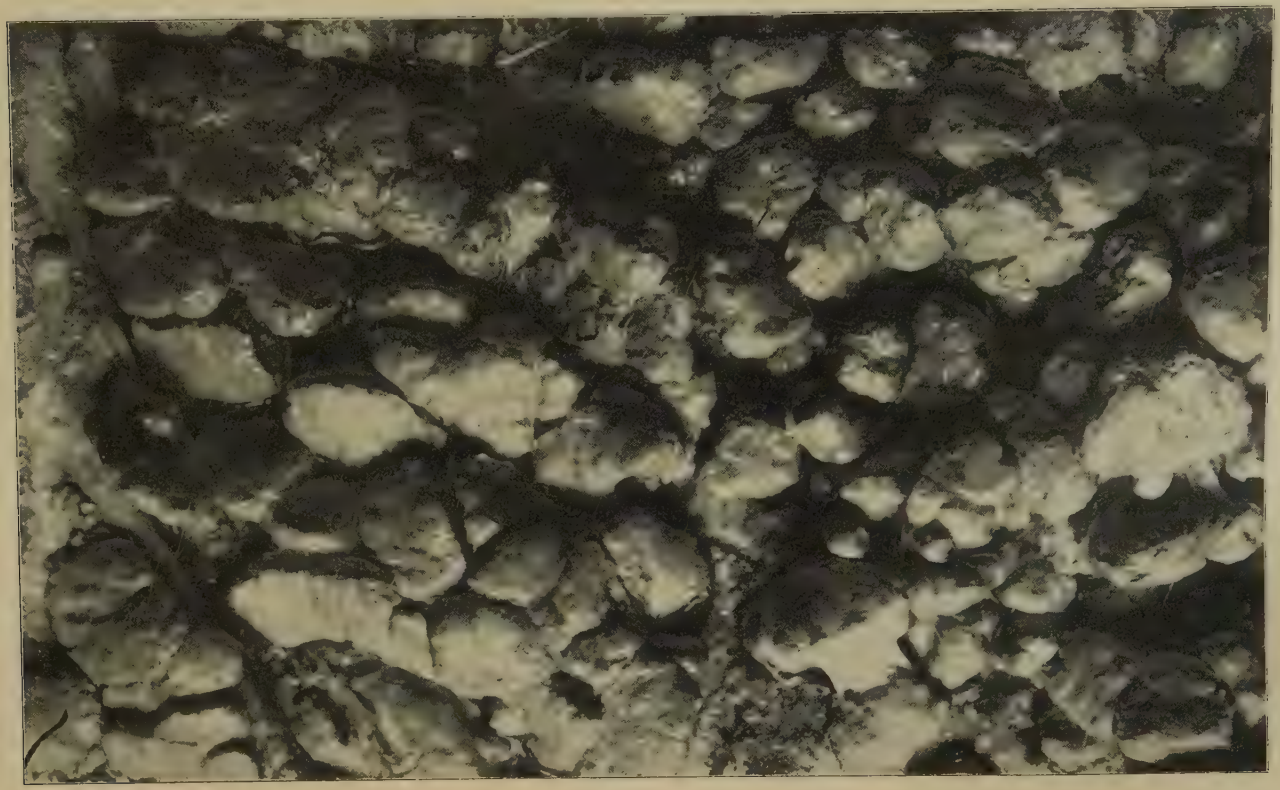


PLATE II.—*Photograph of a portion of tubercular omentum of a cow, showing the tubercles, natural size.*

ful manipulation in almost every case, and, in case of no bacillus being found, is no guarantee of the absence of the disease.

Inoculations with the suspected discharges, secretions or tissues, demand a delay of one or two months before one can pronounce upon the result, and that result if negative, gives no assurance that the animal is free from tuberculosis but only that the material inoculated did not contain the germ.

THE TUBERCULIN TEST.

Much has been said and written against the tuberculin test by those who have never used it, and who are therefore utterly incompetent either to endorse or condemn it, but for those who aim at the prompt and thorough eradication of the infection from a herd, and at the securing at once of a guarantee of progeny, beef and dairy products, no resort can, as regards its efficacy, be at all compared with the tuberculin test.

Tuberculin is a sterile solution of the products of the artificial culture of the tubercle bacillus. In its preparation it has been treated to a boiling temperature which is as fatal to a tubercle bacillus in liquid medium as it is to a hen's egg. But this is not all, even the dead bacilli have been separated from the liquid by passing it through a porcelain filter. The remaining liquid (tuberculin) is absolutely sterile and can plant and propagate neither the tubercle bacillus nor any other living thing. It can poison if given in excessive doses, as alcohol can poison, but it can no more produce the germ of tubercle where that does not exist than can distilled alcohol plant the yeast germ and start a new vinous fermentation. The insane fear of tuberculin is the fruit of an ignorance of its true nature and of a blind prejudice which withholds its victim from informing himself on the subject.

As we produce tuberculin in the bacteriological laboratory of the N. Y. S. Veterinary College, and distribute it free, for use by approved parties in this state, we can speak with confidence of the absolute harmlessness of the agent when intelligently employed. We aim at securing no profit in making this agent, but charge only for packing and shipping. We have therefore no interest in its manufacture, for on the contrary the greater

demand from residents of this state for tuberculin the more unremunerated labor is heaped upon us.

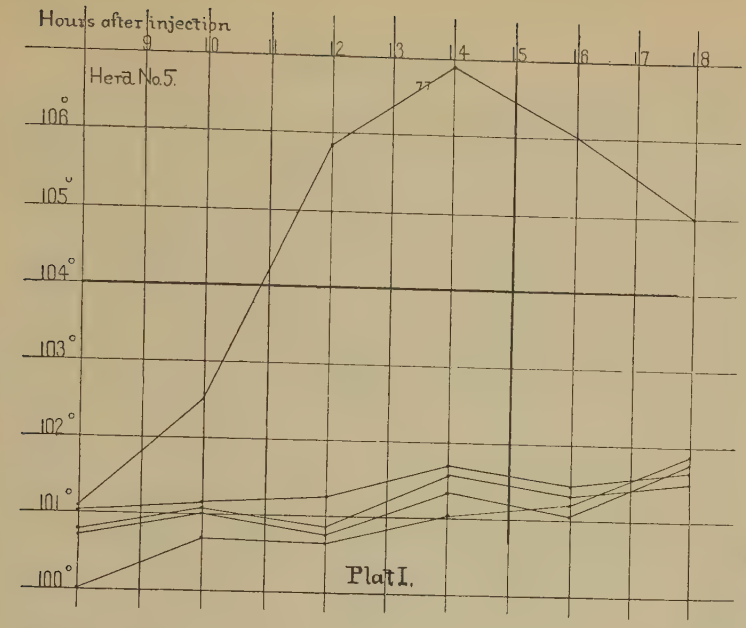
The value of the agent consists in this, that the hypodermic injection of an appropriate dose in a tuberculous animal, however lightly affected, produces in the course of the succeeding twenty-four hours a rise of body temperature and other indications of fever. The gradual rise and fall of the temperature in the absence of any other diseased or physiological condition which would bring this about is the most reliable of all symptoms of the presence of the disease. Upon the sound animal system such a dose of tuberculin produces no appreciable effect.

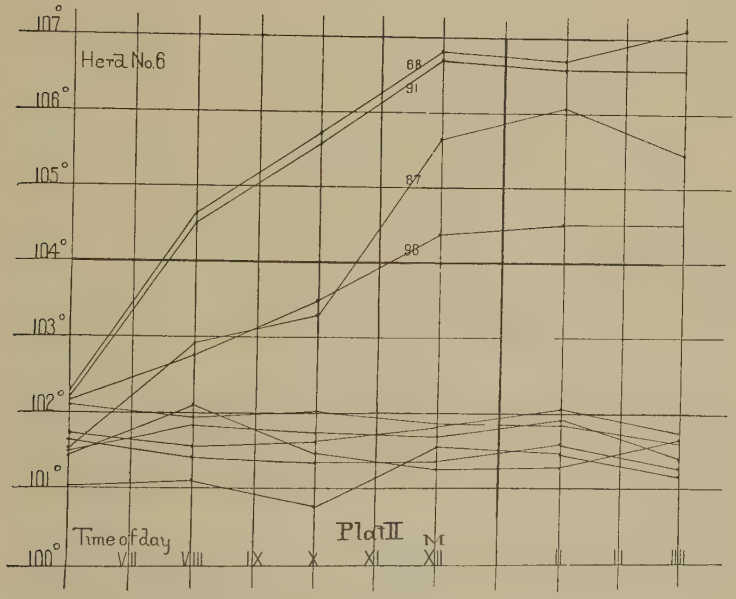
It is important, however, that I should not be misunderstood in this matter. The man who will use tuberculin without due caution and without due consideration as to the condition and environment of the animal, and who blindly condemns on any rise of temperature will almost certainly condemn non-tuberculous animals and bring the tuberculin test into discredit. The intelligent use of the test, demands an intimate knowledge of the kind of animals tested, both in the healthy and diseased condition, and a careful scrutiny before and during the test.

1st. *The subject must be in good general health.* If there is present in the system any concurrent disease it may undergo an aggravation within twenty-four hours and give a rise of temperature that will be mistakenly set down for tuberculosis. At the very start, therefore, it is important that the general health of the subject should be first assured by a critical professional examination. If some other disease is present the tuberculin test had best, as a rule, be delayed until that has subsided, while if tuberculosis is found the test will be superfluous.

2d. *The subject must not be within three weeks of parturition, nor about to abort.* In many cases, though not in all, as preparations are made for calving, the system becomes unduly susceptible to the presence of tuberculin and that agent will cause a rise of temperature, though no tuberculosis is present. Unless this source of error is carefully guarded against the most valuable cows in the herd may be condemned unjustly.

3d. *The cow must not be within three days of the period at which "heat" would naturally occur.* Under the excitement of œstrum





TEMPERATURE CHARTS

4.—*Temperature curves of 5 cows, all of one herd, under the tuberculin test. No. 77 was tuberculous, the other, healthy.*

5.—*Temperature curves of 10 cows, all of one herd, under the tuberculin test. Nos. 68, 87, 91 and 98 were tuberculous, the others healthy. (Curtice, Report of the Bureau of Animal Industry 1893–6.)*

the body temperature usually rises two or three degrees, and if tuberculin has been used this rise may be attributed to tuberculosis and a sound animal may be condemned. Nor is it always enough that the animal is supposed to be pregnant. Abortions sometimes takes place unexpectedly and unknown to the owner. If, therefore, a cow under the test and which is not well advanced in pregnancy should show a rise of temperature it should be at once ascertained whether the animal is not in "heat." If symptoms of "heat" are found she should be set aside along with any calving cows to be tested again when such a source of error is no longer present.

4th. *The tested animal must not be exposed to a hot sun in a closed area.* In excess this will cause heat apoplexy, and the fever heat which ushers this in may easily be mistaken for the indications of tuberculosis.

5th. *Cattle taken from pastures must not be enclosed in a hot, stuffy stable.* While they must be tied up to allow of the temperatures being taken at short intervals, coolness and ventilation should be secured in summer by a sufficient air space and the requisite ventilating openings.

6th. *Exposure to cold draughts between open doors and windows, or to wet or chilly blasts out of doors should be carefully guarded against.* A chill proceeding from any source and alike in the presence or absence of tuberculin causes a rise of the internal body temperature.

7th. *Heavy cows unaccustomed to stand on hard boards may have a rise in temperature in connection with resulting tenderness of the feet.* One must avoid hard floors on the day of the test or make examination of the feet and allow for attendant fever.

8th. *Omission of the previous milking or a change of milker and consequent retention of part of the milk* will raise the temperature of a nervous cow, and in careless hands secure an erroneous condemnation.

9th. *Privation of water at the regular time will often cause rise of temperature* especially when on the dry feeding of winter. I have seen a general rise of two degrees and upward from the delay of watering for a single hour, while after watering the temperature went down to the normal and remained so. Water

always tends to a temporary lowering of temperature but in the presence of tuberculosis it soon rises again.

10th. *Change of food is liable to produce a slight indigestion and rise of temperature.* This should be avoided as far as possible, and when a herd is taken up from pasture for the test it should have grass, ensilage or other succulent food.

These are examples of the sources of fallacy which attend on the reckless and unintelligent use of tuberculin. They only show that skill and training are necessary to its successful use, and that in the absence of these the apparent results are not to be too unhesitatingly accepted. In all cases, in the absence of the requisite education and experience it is desirable that the animals which have shown a rise of temperature should be separated from the herd and tested anew after the lapse of three or four weeks. In this way such errors may be almost entirely excluded.

11th. *An animal with advanced tuberculosis sometimes fails to react.* The subject, is, however, usually emaciated and bloodless, breathes hard and has rapid pulse on exertion and shows unequivocal symptoms of tuberculosis to the skilled examiner. Such cases can, therefore, rarely escape a physical examination. They are noticed mainly to guard against the mistake of making the rise of temperature or its absence the sole test of tuberculosis.

12th. It is objected to tuberculin that it detects even the slightest and most latent cases of tuberculosis, some of which would recover and many would remain useful for years. This objection would be valid if our object were to obtain the greatest possible money return from the individual tuberculous cow at the expense of any risk to the sound herd. But tuberculin is, and should be used for the purpose of a complete eradication of the tubercle bacillus from the herd and the preservation of a sound stock which with its products will be above suspicion. If this is not aimed at ; if the latent cases are to be retained in the herd and the advanced cases only removed then truly tuberculin should have no place in your system. Physical examination should be all sufficient for your purpose. But you could not place the herd at once above suspicion, you could not sell its members with a guarantee of soundness, and you could not assure the consumers that the uncooked dairy products were safe.

The animal with local tubercle may not at the present time be diffusing the poison, but where such animals are preserved one will at intervals have the local tubercle extended so as to cause generalized tuberculosis ; and as this extension necessarily takes place by the conveyance of the bacillus through the blood, and as such bacilli must be circulating in the blood before they can invade new tissues and form new tubercles, it follows that there is always a period between the entrance of such bacilli into the blood and the development of new tubercles in which the blood and all blood-containing organs are infecting, though no symptom nor lesion of new tubercles can be detected. At this stage the animal may convey tuberculosis through its flesh, or through its dairy products, while even a post-mortem examination would pronounce it free from generalized tuberculosis. It is also liable to distribute the germ to other members of the herd before any suspicion of immediate danger is entertained.

Deduction. It may be concluded from such considerations as the above that the tuberculin test is indispensible where one aims at a guarantee of the soundness of the progeny and dairy products of a herd, but that its use demands one of two conditions.

A. That the animal showing tuberculosis under the test shall be destroyed and the buildings where they have been shall be disinfected ; or,

B. That such infected animals, as have the disease in a latent form, shall be formed into a separate herd and kept well apart from other stock, for breeding purposes only ; or if their milk is used that it shall be first subjected to sterilization.

The stockowner who values the sound portion of his herd cannot afford to allow even the latent cases of tuberculosis to mingle with it.

TUBERCULIN IN MODERATE DOSE HARMLESS TO SOUND CATTLE.

The concurrent testimony of all veterinarians drawn from hundreds of thousands of tests is that the ordinary test dose is harmless to a nontuberculous animal. In 1894 I put this to a crucial test on five cows (Holstein, Jersey and grade) injecting the tuberculin on six successive occasions and found that it pro-

duced no appreciable change in the general health as evidenced by temperature, breathing, pulse, yield of milk or quality of milk. I feel accordingly that I can speak with the greatest confidence as to the entire harmlessness of the tuberculin test on a sound animal.

That it rouses into a temporary activity the tuberculosis already existing in the unsound animal is true. Were it not so it would be useless as a diagnostic agent. But if the state stands ready to destroy and pay for the diseased, there can be no possible objection to the temporary aggravation which leads to the purification of the herd.

MEASURES FOR THE ERADICATION OF TUBERCULOSIS.

For the complete eradication of tuberculosis from a herd or country the first and main consideration is the absolute separation of the sick animal and all its products from the healthy. This is fundamental in dealing with all infectious diseases, and if it could be applied would reduce all contagious disorders to the condition of simple sporadic ones. Plagues would cease to be plagues, and the infecting disease would cease like any other affection with the first individual case. The plagues of men follow the great movements of men—pilgrimages, armies, trade. The animal plagues prevail continuously in unfenced territories (Asia, Central Europe, Australia, Tasmania, New Zealand, South Africa), and follow the tract of armies and the channels of commerce. Stop the great accumulations and intermingling of animals and we arrest the general diffusion of a plague and reduce it to the comparatively insignificant importance of some common disease.

Exceptional cases like anthrax and blackquarter in which the germ is maintained for years in the soil, are only apparent exceptions to this fundamental principle, as whenever the germ can thus be carried in soil or water the separation of sick and their products from the healthy is incomplete.

In applying this principle to tuberculosis we meet with the drawback that a great variety of animals of different genera are

susceptible (including the human being) and that it is difficult to keep all these and their products apart, and that further it is not in our power to cut short the disease abruptly in the human race as it is in the lower animals. There is however the counterbalancing advantage that its propagation is slow and takes place less readily through the air than in the case of most infectious diseases.

BREEDING HEALTHY STOCK FROM PARENTS WITH LATENT TUBERCULOSIS.

Where the state is not pledged to exterminate the disease by prompt and radical measures it is quite possible to raise healthy stock from sires and dams that have tuberculosis in a slight and latent form. It will be recalled that calves are usually born free from tuberculosis. In the slaughterhouses of Europe there may be but one tuberculous calf in 100,000 killed. If therefore the calves can be preserved from infection of a parental source they may be raised absolutely sound with very few exceptions. For valuable pedigreed animals especially it is quite possible for the owner to keep those with latent tuberculosis in secluded herds, to remove the calf from its dam as soon as born, and to raise it on the sterilized milk of the dam or on the milk of another and healthy cow.

In such a case it is always desirable to employ the tuberculin test upon the entire herd, to destroy at once those animals that have advanced or generalized tuberculosis, and to separate in a new or disinfected barn under special attendants the cows that have been attested sound. There will remain the slight and latent cases which have reacted under the tuberculin, but which are well nourished, having healthy skins, eyes and appetite, and no cough, wheezing nor shortness of breath. These must be kept well apart in separate barn and pasture where neither they nor their products can come in contact with healthy stock, where they can have good air and nourishing food. Their calves must be kept in a separate building or park, and fed on the milk of sound cows, or on that of their dams after it has been raised to the boiling point for 15 minutes. After sterilization the milk must be put in scalded vessels reserved for the use of the calves,

and fed by the special attendants. Any loss of condition, unthriftiness, cough or scouring on the part of a calf, should be the warrant for separating it from the others and subjecting it to the tuberculin test, and for its destruction in case it shows the tuberculin reaction.

The cows should also be carefully watched and in case any one develops cough, wheezing, breathlessness on exertion, or other sign of actively advancing tuberculosis it should be at once destroyed as endangering the others by possible reinfection. The whole isolated tuberculous herd should be submitted to the tuberculin test, every three or six months, and individuals which fail to react on two successive tests, and which show all other indications of good health may be held to have recovered and may be restored to the healthy herd.

A *second* method is that pursued successfully in the North West Territories. Cows and heifers that have reacted under tuberculin, but which otherwise appear to be in good health, are made into a herd by themselves and placed on a special range apart from all other cattle. They live in the open air with slight shelter in winter and their calves are allowed to suck their dams running with them until winter. The wide range, the open air life, and the early destruction, by sunshine and oxygen, of the discharged microbes, tend in the main to ward off infection except such as comes in the milk, and as a matter of fact the majority of the calves grow up in apparent good health and are fattened and shipped to England.

The climate of our Southern States affords a better opportunity for this practice than does the semi-arctic northwest. There the ranch cattle living in the open air all the year round show little or no tuberculosis, and with this outdoor life the genial climate will greatly favor the survival if not the recovery of the slight and latent cases. It should be added that in the stabled cows of the southern cities tuberculosis is very prevalent.

EXTINCTION OF TUBERCULOSIS WITHOUT THE TUBERCULIN TEST.

As successful examples of this I may quote from my own personal experience.

1st. A herd of about 200 head belonging to the Willard Asylum had become badly affected with tuberculosis and on physical examination, without the use of tuberculin, I condemned about 50 per cent. These were accordingly destroyed and new barns and yards were constructed at some distance from the others and filled with cows selected from the most healthy herds available. These were bred to healthy bulls and a new herd gradually built up. Meanwhile the remaining 50 per cent of the original herd were gradually slaughtered, and like the original half of the herd were found to be tuberculous without a single exception. The original barn was thoroughly cleaned, repeatedly disinfected with chloride of zinc and with its cleansed and disinfected yards was left unoccupied for an entire year. The fields on which the original herd had pastured were used for other purposes than pasture for two full years. The new herd was carefully watched and any cow which contracted a cough or showed especially poor health was at once separated from the herd and disposed of. This treatment of the new herd was kept up for over twelve years, and in the middle of December, 1897, I subjected the mature animals of the herd to the tuberculin test, and found not a single case of tuberculosis. I have never before subjected an untested herd of this size to the action of tuberculin without finding a considerable percentage of cases of tuberculosis. The splendid showing is highly instructive as to the high value of intelligent management even without the aid or tuberculin. Here a large herd was maintained under the same conditions of food, milking and housing (even in the same barns) as the former herd which became universally tuberculous, and, even under the crucial test of the tuberculin, furnished not a single case of tuberculosis. The only difference is that with the present herd intelligent measures were taken to exclude the germ of the tuberculosis. The case is all the more striking that some of the most important precautions against the spread

of tuberculosis in a herd were not put in force. The cows were not taught to keep the same stall on all occasions, but went into any stall that was convenient. Then there were no partitions between the feeding places of adjacent stalls and one cow could lick up the food from the two stalls on the right and left as well as from her own. With an infecting cow in the herd, therefore, there was every opportunity for a speedy spread of the infection. In spite of such obvious opportunity for infection the careful selection of its first members of the present herd, the building up of the herd by home breeding only, and the weeding out of all suspicious animals succeeded in excluding any trace of tuberculosis.

The experiment, however, entailed the entire destruction of the original infected herd, and though the post mortem examination showed that in this instance this step was necessary to a successful result yet in many other less universally diseased herds the larger part could have been saved by picking out the diseased with the aid of the tuberculin test.

2d. In Cornell University herd, which numbers about sixty cattle, old and young, tuberculosis led to the destruction of a number of individuals. The diseased, however, were disposed of as soon as objective symptoms showed the presence of tuberculosis, and after some years of this weeding out when I tested the whole herd with the newly discovered tuberculin I could find no trace of the disease except in a young bull which had recently been acquired from another herd. Since his destruction I have tested them repeatedly, but have found no trace of tuberculosis.

EXTINCTION OF TUBERCULOSIS WITH THE AID OF TUBERCULIN.

If a herd has been bred up from home stock without the introduction of any animal from without, and if for a number of years there have been no losses and no illness suggestive of any form of tuberculosis there is a fair presumption that it is free from that disease. But in the average herd, and especially if sickness or death has occurred, even if such has been attributed to something else, it is a wise precaution to subject the whole

to the tuberculin test. Especially now when the N. Y. State Veterinary College undertakes to furnish tuberculin free for use in herds in this state, the expense of such a test should not be a serious drawback. The measures to be adopted may be thus enumerated.

1st. Apply the tuberculin test to the entire herd.

2d. Remove all animals showing a rise of temperature which indicates tuberculosis.

3d. Destroy and burn, boil, or deeply bury all cases of the disease, unless it is decided to form an isolated herd of latent cases which are in good condition. (See above.)

4th. In case of doubt or disturbing influences which may have caused rise of temperature (nearness to calving, heat, exposure, concurrent disease, changes in management, etc.), keep the suspected animal apart for three or four weeks and test again. This will almost certainly correct any mistake of the first test.

5th. Repeat the test every three months and if two successive tests show no indication of tuberculosis the herd may be accounted safe.

6th. As soon as tuberculous animals have been removed from a stable let it be vacated and thoroughly disinfected with chloride of lime, 4 ounces to a gallon of water and enough quicklime to make a good whitewash, which will show if even a square inch has been missed. When chloride of lime is objectionable because of its tainting the milk, mercuric chloride may be used in the proportion of one drachm to a gallon of water, to which is added one drachm of sal ammoniac and 5 drachms of common salt. This is much more poisonous than the chloride of lime and must be cautiously handled during its application. The walls, roof, and especially the floor, gutter and feeding trough must be first thoroughly scraped, washed and cleaned, all rotten woodwork must be removed and in case of double boarded walls, the boards must be removed on one side to permit of a thorough application.

7th. In making new purchases avoid any herd in which tuberculosis has appeared, or which has had sickness or deaths in recent years.

8th. Don't purchase from city, suburban nor swill stable.

9th. Don't take a cow which is in ill health or low condition, especially one with cough, nasal discharge, foul breath, hard nodules under the skin, diseased udder, swollen loins or joints or a tendency to scour or bloat.

10th. Test every fresh animal with tuberculin before admitting it to your herd, unless it has been recently tested and has not since been exposed to possible infection.

11th. Don't admit strange cattle to house, field or yard with your own. Keep them apart until tested with tuberculin.

12th. Keep each animal in your herd strictly to its own stall and manger.

13th. Board up the partitions of the stalls in front so that no two cows can feed from the same manger nor lick each other.

14th. Be especially observant of the older cows and on the slightest sign of ill health separate and subject to the tuberculin test.

15th. In case a herd of cattle is found to be tuberculous subject to the tuberculin test all the domestic animals that have mingled with them freely and fed from the same troughs. Remove those that show a reaction.

16th. Exterminate the vermin (rats, mice, sparrows) in a building where tuberculosis has prevailed.

17th. Let no consumptive person attend on cattle or other live stock, nor prepare their food.

EXTINCTION OF TUBERCULOSIS BY STATE ACTION.

It is out of the sphere of the private breeder or dairyman to enter on the question of state sanitary police, yet no one is more deeply interested in the general enforcement of such measures as would banish the existing dangers which attend on the purchase of strange animals and their products. In recent years the rigid supervision of herds in the New England States has driven many infected cattle into New York to spread tuberculosis in previously healthy herds, and to increase it in those that were already affected.

The exclusion of cattle seeking to enter Pennsylvania or the New England States, which were not accompanied by the certificate that they had successfully stood the tuberculin test, has

led to the testing of western cattle at Buffalo, Albany and elsewhere, and the detention of such as failed under the test, to be sold too often to the unsuspecting New York stockowner. The tests have often been made by the inspectors of the Bureau of Animal Industry, who have no legal right to inferfere with the condemned cattle unless the attempt is made to move them into another state, and in the absence of any restriction by the municipal or state health officers, the owner or dealer is at liberty to sell such tuberculous cattle in open market.

If the test is made by a veterinarian who is not a national nor state official the same holds true; he has no authority to forbid the sale of the diseased and condemned cattle.

Again, private stockowners have had their own herds tested, and have removed from the herd those that failed to stand the test, but there is nothing to show what became of such condemned animals, and in the absence of a state indemnity and slaughter, there is much to be suspected.

These are hints of the evils that have been precipitated for a length of time upon our New York live stock industry. Day by day our herds are being systematically infected by the introduction of the tuberculous offscouring of other states and of our own, and we raised not a finger to stop it.

Further, in the interests of the consuming public we have to consider that we have no inspection in our little local abattoirs and no guarantee of the meats there killed. And meanwhile we are giving free rein to every evil disposed dealer, to add to our herds the tuberculous animals drawn from the states around us.

The crying need of New York to-day is first to block these streams of infection, which are now practically invited into our herds from other commonwealths, and second to inaugurate a systematic effort to rid our own herds, which are the sources of our dairy and meat products from this scourge.

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Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.

Exterminating Texas Fever.

[*From* THE COUNTRY GENTLEMAN, *Nov.* 3, 1898.]

EDS. COUNTRY GENTLEMAN—Will you kindly advise how to remove the small ticks on cattle which are said to cause or transmit Texas fever?

What causes these ticks? Is it well settled that the fever is caused by these ticks?

When cattle with this fever have been pastured in a field, how soon can the field be used again for pasturage without danger?

What is the proper remedy for such fever?

Is there any danger of such trouble after frost? W. N. W.

Another correspondent writes for advice in connection with losses from this disease in a herd of cattle in Albemarle County, Va. They had been in no way exposed to other cattle, nor on or near a highway, but had access to the woods. A small pack of hounds kept on the place had ticks on their skins. Other letters on the same subject are received. In reply, we have been able to secure the following valuable article from that eminent authority, Prof. JAMES LAW.—EDS.

The Cause of Texas Fever.

The cause of this disease was demonstrated by Dr Theobald Smith of the Bureau of Animal Industry to be a protozoön (*Pyrosoma bigeminum*), which is usually met in pairs as microscopic pyriform bodies in the interior of the red blood globules. These lead to the breaking down of the globules and the diffusion of their constituents, including the red coloring matter, through the blood serum and tissues. White tissues like fat are colored yellow, and the urine is changed to a blood red or black color by reason of the passage of an abundance of this pigment. The mucous membranes lining the eyelids, nose and other passages are usually of a deep yellow. The temperature of the body rises to 104°, 106° or 108°, and pulse and breathing may be greatly accelerated. The animal usually becomes heavy, dull and stupid as the disease advances, though in some cases it is nervous and excitable. The muzzle is usually dry and, like the horns, ears and hoofs, and to a less extent the general skin, very hot. A careful examination of the skin will detect the presence of the cattle tick—the *boöphilus bovis*.

The Agency of the Tick.

That the tick was in some way connected with the disease was recognized in the earlier half of the present century, but the presence of wood-ticks elsewhere, where Texas fever was unknown, tended to discredit the vulgar belief; and it was only when the protozoön was found in the blood of the infected animal, and in that drawn into the stomach of the tick which adhered to the skin, that a sufficient explanation was obtained. Then abundant evidence was accumulated to corroborate the conclusion. Southern cattle from which all the ticks had been carefully picked were no longer infecting, and might be carried north and placed among susceptible cattle without risk of injury to the latter. Northern susceptible cattle could be carried to the infected districts in the south and preserved from the disease, provided they were kept rigidly indoors, and never allowed to come in contact with the ticks. Yet the blood taken from the infected animal and injected into the susceptible one produced the disease, the syringe, in place of the tick, becoming the bearer of the germ-bearing blood. Finally, fields which were securely fenced and left for an entire year without the admission of cattle might in the second year be safely pastured by susceptible cattle. The ticks in this case had perished for lack of the bovine host to carry them through an essential stage of their existence.

Development of Tick and Disease.

The adult cattle tick is an eight-legged parasite of the ox, and from this the development may be easily traced. In a bottle plugged with cotton, the females may be seen to lay eggs in from two to four days, and in three or four weeks, at a temperature of 70° to 80°, these eggs hatch out a mass of six-legged larvæ. If kept very hot (80° to 90°), the incubation may be shortened, so that the young appear in fifteen days. The young ticks, if furnished with a little earth or leaves, may live through an entire winter—five or six months—without further development. The condition of further development appears to be the parasitic life on cattle. If the six-legged larva is placed on an ox, it molts a week later, and emerges from the old skin as the eight-legged nympha. After a second week, lived on the skin of the ox, it molts a second time, becomes sexually mature, and is ready to reproduce its kind through egg-production.

The incubation of the tick in a variable time according to temperature, explains the varying lapse of time in different cases, between the exposure of susceptible animals and the appearance of the disease. If southern cattle infested by the ticks have passed once over a highway or pasture, and have left behind them the mature ticks, which have laid their eggs and died, it will take three or four weeks, at a moderate temperature, for these eggs to hatch out larval ticks which are capable of conveying the disease. Susceptible cattle, therefore, which have followed the southern stock on the same pasture, a day or two after the latter have passed, will not show the disease for about a month after the commencement of such exposure on the tick-infested pasture. Cattle may even be pastured on such land for a week or more after the southern cattle have passed, and yet escape infection. The explanation is that there was during this time no active living tick to seize upon them and inoculate the deadly microörganism. The case would be different if young ticks, before or after their first molting, had been dropped on the pasture, as these not having completed their full round of existence,

would promptly seize on any available cattle as hosts on which they could live to full maturity, and in doing so would transmit the infection. Similarly, after the development of the first crop of larva from the eggs laid in the pasture, the latter remains infested for the entire summer season, and animals placed upon it may become tick-infested and sicken in a few days. This latter condition is that of unfenced ranges and open woodlands in the southern States, within the Texas fever area, in summer.

Relation to other Domestic Animals.

The cattle tick is preëminently the parasite of the bovine race. If therefore a pasture can be thoroughly secluded from cattle for a year, the tick, which requires an animal host to enable it to reach maturity, almost of necesity perishes, and the pasture is rendered safe. Whether the tick can become parasitic and mature on any other domestic animal has been questioned. I have found what appeared to be the cattle tick on the ears of horses. The ticks commonly found on dogs are usually of a different species. With their insatiable appetite for blood, it would not be surprising if the cattle tick should occasionally seek in other animals sanguineous food which is essential to their further development to maturity; yet experience shows that this is at best an exceptional resort, and that if the bovine host is excluded the danger of their propagation is reduced to a minimum.

Susceptibility and Previous Exposure.

Stock owners in the South often find that the disease prevails in a fatal form among thoroughbred cattle, while it has little or no effect on common stock. They are tempted therefore to conclude that high-bred cattle are more susceptible. The true explanation is that thoroughbred cattle have either been recently imported into the South, with all their native northern susceptibility or, in order to preserve the purity of their offspring, they have been confined to well fenced pastures, to which the common cattle which run in the woods and unfenced ranges, have no access. If therefore the fenced pastures of the thoroughbreds, have been laid down in grass after culture of other crops, or, if they have been left for an entire year without depasturage by cattle of any kind, the ticks are exterminated, and the thoroughbreds placed on such fields remain as susceptible as if they had but newly arrived from the North. When, on the contrary, infected and tick-covered cattle are carried from near the Gulf of Mexico into one of our northern States, and when, in the summer season, northern cattle follow these upon the same fields, the infection seizes all without discrimination, and the veriest scrub, shows no more resistance or tolerance, than the most aristocratic Short-Horn, Devon, or Jersey. On the contrary if the blue-blood thoroughbred has first seen the sun on the coast of the gulf, she shows the same immunity from the disease as is possessed by the southern scrub, and if carried north will convey the infection to the common cattle of the North in as deadly a form as if she were one of the long-horned Texans of thirty years ago. Insusceptibility belongs to no race or breed, but is simply the result of a previous exposure to poisons poduced in the system by the disease germ, and to the acquired power of tolerance and resistance that comes from a mild, non-fatal attack. In the same way cattle that have grown up in an area of rinderpest, lung-plague or anthrax are immune from the disease in question; they have survived an exposure to it in early life and are thereafter to a large extent proof against its invasion.

Treatment of Texas Fever.

The treatment is exceedingly unsatisfactory, since by the time symptoms are observed, there has already been such extensive destruction of blood globules and consequent impairment of vital functions, that the victim is virtually beyond help. Moreover the germ (pyrosoma) has colonized itself in the blood and tissues, where it is multiplying with great rapidity, and any antiseptic or germicide which can be introduced into the circulation in quantity sufficient to check this increase, or to kill the parasite, is quite as dangerous to the living cells of the blood and tissues. Mild cases will recover under the internal use of antiseptics (such as carbolic acid in drachm doses, associated with copperas (2 to 4 dr. doses), or other preparation of iron, but slight cases occurring in the south in partially immune animals, usually recover without treatment.

Prevention of Texas Fever.

Our first object must be to prevent the inoculation of the fatal germ carried by the tick. This may be done by removing the ticks from the skins of cattle coming from infested districts and placing such cattle on tick-free pastures. Infected cattle that are kept free from ticks, may mingle with susceptible cattle on the same pastures, or in the same buildings, cars, loading banks, yards or vessels without proving a source of danger. For the same reason southern cattle from infected lands can be safely shipped north after the ticks have been destroyed or rendered torpid by the first killing frosts of winter, and until they are again called into activity by the returning heats of spring.

The ticks may be picked by hand from all parts of the skin of cattle that are about to be put on tick-free pastures, care being taken that the cattle are protected against taking on others from the grass or brush before entering the protected field.

Again, the parasite may be destroyed by a coating of oil on the animal host, since, like other insects, they breathe by spiracles on the surface, and if these are blocked by the oil, the insect is suffocated. A liberal application is necessary, but any kind of bland oil will serve the purpose—whale oil, crude cottonseed oil, lard oil, sweet oil. The oil may be applied by means of a sponge, special care being taken to cover the whole skin, and particularly the more delicate parts, in the groin, or inside the fore and hind limbs.

A wholesale method of applying the oil is to make a bath just wide enough for the ox to walk through, deep enough to immerse its whole body, and having two inclined planes at the two ends for the animal to walk down into it and up out of it. The bath must be watertight, and may be sunk so that its upper edge is on a level with the ground. It is filled with

water, on the surface of which a thick layer of the oil is floated. In walking up the inclined plane out of the bath, the ox receives a coating of oil, and if delayed a short time before leaving the incline the surplus oil will drop off and run back into the bath. The efficiency will depend somewhat on the slowness with which the animal walks out, so that the layer of oil may remain unbroken and leave an inunction on every part of the skin. Cattle dressed in this way may be shipped north, or turned into a tick-free pasture with comparatively little danger.

To make the oil more effective, it may be medicated with one of various agents that are poisonous to the ticks. Thus before distributing the oil on the surface of the water it may be thoroughly mixed with oil of tar in the proportion of one part to twenty parts of oil.

The Bureau of Animal Industry recommends as the best and at the same time a cheap dressing a mixture of 300 lb. of flowers of sulphur and 3500 gallons of extra dynamo oil, the combination being made while hot. This is a perfectly non-poisonous and non-irritating application, and is probably the most trustworthy that has yet been brought forward.

Immunizing Cattle.

Cattle born in the infected district grow up comparatively immune. It may be supposed that, inured to the poisons of the Texas fever germ, communicated through the uterine secretions and milk of the dam, if not indeed to the germ itself passing into the blood of the fœtus before birth, they acquire a tolerance, such as that of an animal that has had a non-fatal attack of the disease, and when infected by the ticks it either shows no visible disorder or has the malady in a mild form. Attempts to give immunity by long continued use of the food and water of an infected locality have, in the absence of the ticks, failed to furnish immunity. In an experiment of the Bureau of Animal Industry, northern cattle were kept for an entire year indoors, or in tick-free fields in an otherwise infected district in Alabama, and fell victims to the disease at the end of the year, as soon as they were exposed to the ticks. Immunity, then, cannot be secured through any soluble products of the germ that may be present in the drinking water. Drs. Connoway and Robert and Prof. Dodson in the same way affirm of the Texas fever blood after it has been sterilized: "It contains neither a toxin nor antitoxin that is potent to induce a permanent or even a transient immunity." Dr. Francis, operating on young calves, claims better results; he had but two deaths in 45 treated.

Immunization has however been secured by inoculation of minimum doses of the fresh blood of infected cattle (Bureau of Animal Industry), and by using a minute dose of the defibrinated blood (Australian Report).

A method which has been found effective in the hands of Drs. Connoway and Robert is to infest the susceptible animal by setting free on its skin about 25 ticks, and when the animal has recovered from the resulting fever to infect it anew by applying about 100 ticks. In this way they have succeeded in inducing immunity with a very small percentage of loss, so that they recommend the method for thoroughbred cattle that are to be shipped south. The danger is much less to calves than to adult animals, and as carried out in cool or winter weather, rather than extreme heats.

Yet in all such cases a certain proportion of the animals operated on die of the resulting disease, so that these means cannot be advocated as thoroughly satisfactory. A still more serious objection is that the method aims at saving the individual animal only, and has no tendency toward diminishing the number of ticks or the danger to susceptible animals (born or imported) toward contracting the disease. It contemplates the infecting material remaining in the district to the end of time. It may pay to immunize valuable thoroughbred animals that are to be introduced, but to propose to apply this on all the common stock, is to pronounce its condemnation. The cost would be prohibitory.

Eradication of Texas Fever.

The most important question after all in connection with Texas fever is the possibility of eradicating it from the continent. This would entail legislation and administration in each infested State, which would lead to the universal destruction of the pathogenic cattle tick. Such a result is undoubtedly practicable, and if practicable it becomes the duty of each State to take the necessary steps to put it in operation. If it is feasible to rid a farm of the ticks by judicious fencing and non-pasturage for a year of each field in succession, it is quite as much so for a State to enforce fencing and the alternate use of different enclosures on successive years until the tick has been done away with. This entails, of course, that pasturage of cattle shall be prohibited on all open, unfenced land, and there will be some outlay or loss in fencing or in the temporary loss of pasturage. But the perennial advantage that must come from the achievement will far more than compensate for any such temporary loss. Infringement of the law should of course be visited by a legal penalty, as it would be by the very natural one that the survival of the ticks on the pastures would necessitate a continuous quarantine of such pastures and herds until the ticks had been thoroughly exterminated.

Under present conditions, the cattle industries of the South are so handicapped by this disease that they cannot profess to compete with those of the North. Northern States at present refuse to admit, during the warm season (from frost to frost), any cattle coming from the southern infected region. Southern live-stock owners are therefore debarred from the northern market except during the period of cold weather. Nor can the southern stock-owner import northern cattle for the improvement of his herds except under the most rigid precautions of seclusion indoors for from three to six months after their arrival. Even then there is no absolute certainty that they can be safely turned out into the southern pastures. Unless such imported cattle have been infected and immunized, they cannot be safely trusted on the tick-infected pastures. It cannot be denied that even the native-born and immune southern cattle suffer to a certain extent from the infection implanted by the ticks. On the luxuriant pastures of lespedeza and Bermuda

grass, and with rich soiling on corn, cowpea, &c., under a sun which should conduce to rapid development and fattening, the cattle can with great difficulty only be got into what would be considered as prime condition in Chicago or New-York. When slaughtered, they show abnormally large spleens and a condition of the blood which bespeak the harmful operation of the Texas fever blood-parasite. These cattle do not die, they do not even visibly sicken, but they fail to attain to the splendid development which the rich southern field products should secure. The loss which is sustained by this general inferiority of the southern cattle is enormous. But this does not give the full measure of the loss; for in the absence of this embargo on the industry, a much greater area would be devoted to stock-raising, and in a land where continuous outdoor life is possible, and where one can therefore discount tuberculosis and other pests of close stabling, a rich harvest could be reaped in both beef and dairy products. The banishing of the tick, and of the fever which it carries, would make the South a most desirable field for the production of high-class cattle products which could be put on the market with a guarantee against infection communicable to man.

The prospective increase of cattle would amply compensate for the temporary inconvenience of the necessary restrictions on the present comparatively small numbers of the bovine race in the South. On the 55,414 square miles of Illinois, the census gives over 3,000,000 cattle. On the 338,307 square miles of the seven coast States from Virginia to Mississippi, there are but 4,395,503. If stocked as heavily as Illinois, these States would support over 18,000,000 head. These, at $15 per head, would represent $270,000,000. The improvement in quality of the cattle and the enhanced prices of the cattle products would greatly increase the general value.

To make such a movement effective, however, it must be made a subject of State legislation and administration. The private owner can, it is true, rid his own fenced pastures of the tick and his herds of the disease, but his security depends on the perfection of his fence. Let this be broken down by an act of carelessness or malice, or by a storm or fire, and the tick-infested cattle of his neighbor will enter and render his pasture deadly for over a year to come. Or his own treasured cattle may escape into a tick-infested place, which will be their sure death warrant, and the occasion of loss or ruin to the owner.

Then, again, it may be affirmed that, under the present condition of things, the private owner, who has protected his herds at the cost of much care and outlay, must continue the same precautions, year by year, without hope of relief, since, unless every other private owner can be persuaded of the value and importance of the step, and will undertake it in the same enlightened spirit, the surrounding country must remain for all time a source of the greatest danger, and he cannot even drive his protected animals over a highway without exposing them to almost certain death. Every negro, who turns his scrub cow out in the woods or on the commons, will undo the best directed efforts of any combination of private owners of herds.

On the other hand, a statute thoroughly enforced, which will close for a year or two all unfenced woods and ranges against cattle, and which will divide all enclosed pastures into separate fields, with a neutral zone between, and will provide that no field shall be occupied on two successive years by bovine animals, will practically ensure the extinction of the ticks in the course of two or three years. Should it even be discovered that any other animal than the ox acts as a host of the cattle tick at any one point, it will be easy to extend the prohibition so as to include such animal, and to carry the work to a complete success in a year or two longer. The resulting development of the entire South would abundantly compensate for any such delay in any particular quarter. For be it noted, that a success of this kind, like all true sanitary triumphs, is a lasting one. The ticks once exterminated, can never be restored, unless the eggs or insect should be reimported from abroad. There would therefore be no longer any reason for the prohibition of pasturage in woods or on commons All the liberties of the present would return, each freighted with a value which it never bore before, and the southern States would become the home of fine cattle, and the source of the best bovine products.

A further consideration comes up. The south of Mexico, the West Indian Islands, and the Central and South American States, all harbor the disease known to us as Texas fever, and our freedom from its ravages cannot be secured unless we prohibit the importation of cattle from these States. If they, too, would learn the lesson, and could eradicate the cattle tick, then their cattle might be safely admitted; but until this has been assured beyond any shadow of a doubt, the only course of safety is an absolute exclusion.

But the eradication of the cattle tick from the West Indies and tropical America is not the simple question that it is for our southern States. Where there is no frost, and practically no winter, the larval tick, which has an almost indefinite power of survival, may easily live until the following year, so that the pastures would require to be abandoned of cattle for a much longer period in order to insure the destruction of the offending insect. The same may hold good for some parts of Florida and of the gulf coast, and islands of some of the States west of Florida, so that they might require a much longer period of quarantine and vacating of pastures than in the case of the great body of the States now infected. But the quarantine of such a small area, even if permanent, would be of small account as compared with the serious losses to which the southern States are now subjected on account of this disease.

The adoption of such a measure as proposed would demand that careful provision should be made to meet the different conditions presented at different points. These, however, are mere matters of detail, which can be satisfactorily worked out by any one who is intimately acquainted with the pathology and causes of the malady, and which need not be introduced into this already lengthy article.

Contagious Abortion in Cows.

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Forms of Abortion.—Cows are liable to abortion from a great variety of causes, some of which, like mechanical injuries, are purely individual to the animal and show little tendency to extend to other members of the herd. Other forms attack a considerable proportion of the herd at the same time, or in succession, and thus appear as if they partook of a contagious character. In many such cases, however, the implication of a number of pregnant cows in the same herd is only a common result of a special injurious condition, to which all are alike exposed, and the removal of this is the signal for the disappearance of the disease. Thus unwholesome food of all kinds which undergoes fermentation in the first stomach, causing the accumulation of gas (bloating) will at times cause a wide-spread abortion. The consumption of ice-cold water usually stimulates the womb to contraction and the unborn calf to active movements which can be easily observed in the right flank. This, frequently repeated or carried to excess in susceptible animals, will at times cause abortions. The consumption of irritant vegetables, which have a special tendency to act on the kidneys or womb, are causes of general abortions in herds. Ergoted grasses have long been known as causes of abortion, and the same remark applies to smut and several other fungi. It is true that these cryptogamic vegetable products vary much in their character and strength according to the variations of the season, and the local conditions under

which they grow, as well as the time or stage at which they are harvested, so that the ergots and smuts of one year appear to be comparatively harmless, while those of another year, or season or locality are very injurious. The fact remains, however, that under given conditions of growth they are unquestionably causes of abortion, and in such cases the abortions are wide-spread in the herd or in different herds in the same district. Cases such as these are easily mistaken for contagious ones, though there is in the system of the aborting animal no self-propagating germ which would produce the disease if transferred to another animal. Still other conditions may produce wide-spread abortions in the absence of any specific contagious germ. On the magnesian limestones of New York cows are very subject to small stones in the kidneys during the dry feeding of winter, and when this is added to other existing causes, like the riding of cows in heat, attacks made with the horns of their fellows, squeezing in half-closed gates, over driving, sloping stalls, or too laxative food, abortions are likely to be induced. In other susceptible animals the proximity to a slaughter-house, the sight and smell of dead carcases, or carrion, etc., will excite a pregnant cow to abortion.

The Contagious Form.—Any of the usual causes of sporadic or accidental abortion may co-exist with the true contagious element and give unusual energy to it, yet it is of the utmost importance to identify the contagion in all cases in which it is present as the essential cause. This can usually be done by a careful inquiry into the history of the outbreak.

When a herd has been continuously healthy up to the time of the introduction of a cow brought from a herd where abortion has been prevailing, and when, following her advent, one and another and another of the original numbers of the herd abort, without any apparent cause in the way of change of feed, water, barn, stalls or general management, the evidence of the introduction of the element of contagion by the cow in question is very circumstantial and forcible. If pregnant cows standing next to the new cow or near to her are among those that early abort the argument for contagion is still further corroborated. If the

trouble continues in the herd year after year, attacking fresh animals some months after their purchase, the case becomes still stronger.

Or take another case. A cow is sent from a herd to be served by a bull which has been allowed to serve an aborting cow, and her resulting pregnancy is terminated by abortion before the regular time, and this is followed by successive abortions by different animals in the previously healthy herd. Upon the face of it, an outbreak of this kind is manifestly contagious, and in the absence of any other appreciable cause for the trouble, it may be safely held to be so.

Or, a bull is brought from a herd where abortions have taken place, and after his arrival the cows begin to abort, the first cases being in those which the new bull has served. The occurrence is manifestly due to contagion.

Or, a newly purchased cow aborts, and is disposed of in consequence, and another cow, placed in the same stall, in due time aborts also, and others follow in due time, especially those that stood next to or near to this stall. Everything points to an introduced contagion.

Such indications might be varied indefinitely, all variations, however, having the one thing in common, that the evidence of infection stands out prominently and unmistakably. The infection may have been evidently carried by the tail, tongue, soiled stall, litter, gutter, rubbing post, fence or other object, yet the fact of contagion can be demonstrated with reasonable certainty.

These conclusions have been repeatedly affirmed by actual experimental transmission. The Scottish abortion committee found that healthy, pregnant cows often escape, though standing near or even next to an aborting cow, but that when a piece of cotton wool was inserted in the vagina of the aborting cow for twenty minutes, and was then transferred to that of the healthy one, the latter invariably aborted. Galtier found that the infecting vaginal mucus of the aborting cow, when transferred to the same passage in other animals, caused abortion in the sow, ewe, goat, rabbit and guinea-pig; whilst if it was intensified by passing

through the rodents, it would similarly affect the mare, bitch and cat.

Bang subjected two cows, which were three months pregnant and had come from healthy herds, to repeated vaginal injections, with the products of culture of the abortion bacillus in serum glycerine bouillon. Three injections were made on April 14th, May 23d and June 4th, and on June 24th one cow aborted. The other was ill, and when killed she was found to carry a dead fœtus. Pure cultures of the abortion bacillus were found in fœtal membranes and liquids of both animals.

Casual Infections.—In a case which came under the observation of the writer recently, a family cow, kept in a barn where no abortion had previously occurred, was taken for service to a bull in a herd where abortion was prevailing, and though she was only present at the latter place for a few minutes, she aborted in the sixth month.

Another cow, from the same aborting herd, was taken into another herd at a distance of about two miles, and where abortion had been unknown up to that time, and some months later a cow standing in the next stall to her aborted. The remainder of this herd was sold soon after, so that the further progress of the disease could not be easily followed.

Jansen, as quoted by Sand, reports the case of a cow from an aborting herd having been taken into a herd that had been previously quite free from the disease. Soon after her arrival she aborted, and later cow after cow of the original herd aborted. The owner kept the matter secret, and sent his cows to a neighbor's bull for service, with the result that for two years abortion prevailed among the cows served by this bull.

Tobiassen quotes the case of a cow in an aborting herd, which calved a fortnight before the regular time. The calf was at once sent to another farm where no abortions had occurred, and placed in the same building with the pregnant cows, all of which later aborted. The outbreak thus started lasted for several years.

J. R. Jansen reports that a cow brought from an infected farm, for fattening purposes, proved to be pregnant and finally aborted,

and that twenty-four of the pregnant cows on the farm aborted in the same year.

Mörck reports that a cow which had aborted a fortnight previously was taken to a farm where abortions had never been known. She aborted during her next pregnancy, and so did all of the herd, nine in number.

Christensen records the occurrence of a general abortion in a previously healthy herd, members of which had been sent for service to the bull of a neighboring aborting herd.

Uygaard reports that a bull from a healthy herd, but which had been allowed to serve some cows from a neighboring infected herd, was sold to go on a previously healthy farm, where he was put to fourteen cows only. Of these twelve aborted, while the other cows, served by another bull, remained well.

Cases like the above are not to be explained by some imaginary unwholesome conditions of the environments, since in every instance the surroundings of the animals and the conditions of life remained the same, and the only appreciable cause of the outbreak in every case was the contact with an animal from an aborting herd.

Experimental Infections.—Any possible doubt however, may be removed by the cases of experimental transmission of the disease, by the transference of the mucus from the vagina of an aborting cow, to the vagina of a healthy pregnant one. The experiments of Bang have been already quoted.

The Scottish Commission (Woodhead, McFadyean and Atkin) took a pregnant cow from a healthy herd and placed her in a stable where a large number had aborted. They also inserted into the vagina of this cow a plug of cotton wool, which had been left for twenty minutes in the vagina of a recently aborted cow, which had recently aborted. This was repeated the next day, the plug being left in the vagina for several hours on each occasion. Within a month some indications of a threatened abortion showed themselves, and a seven months calf was dropped on the seventieth day after the inauguration of the experiment.

In a second experiment, a cow six months in calf and taken from a healthy herd, was placed in a stable with an aborting herd and a quantity of vaginal mucus from a cow which has recently aborted was injected under the skin of the vulva. She calved prematurely at the end of the eighth month.

Willamsen, when treating a herd for abortion took a piece of the afterbirth of an aborting cow and rubbed it on the vagina of a healthy cow of his own, which had a habit of carrying her calf fourteen days over time. Five days after she had premature parturition.

He took a fragment of the foetal membrane from the cow just named and rubbed on the vagina of a pregnant cow, condemned to slaughter for tuberculosis. In seventeen days the cow aborted.

Abortion Germ.—A number of investigators have sought assiduously for the germ of abortion. More than twenty years ago Franck attributed the disease to *leptothrix vaginalis*, a spherical organism united in chain form.

The Scottish Abortion Commission isolated no less than five different bacteria from the abortion membranes and vaginal mucus, but failed to identify any one of these as the essential cause of the disease.

Nocard found in the fibrino-purulent matter between the chorion and womb, in aborting animals, two different organisms, a micrococus (globular microbe) isolated or united in chains of two or three or more, and a short thin bacillus (rod-shaped microbe) isolated or attached together in pairs. These he did not find in healthy pregnant cows. They seemed to have no evil influence on the animal in the intervals between pregnancies, so that he concluded that they caused disease of the foetus and foetal membranes alone and did not affect the womb or pregnant animal. He allows, however, that the germ can survive in the unimpregnated womb until the next pregnancy, and may thus be kept up for years in the same animal.

Galtier on the other hand has conveyed the disease by feeding and inoculation of the milk or abortion membranes, to the sheep, goat, pig, rabbit and guinea pig, and claims accordingly that the

disease is one affecting the general system of the pregnant animal and that the germs can be conveyed through the blood to the womb. He claims that the germ is intensified in force by passing through the body of the rabbit, or guinea pig and can then infect horses, dogs and cats.

Chester of the Delaware College Agricultural Experiment Station, found in the placentæ of aborting cows a bacillus, which in form and habit of growth closely resembled the common bacillus of the large intestine (bacillus coli communis). In the fermentation test however, it showed a marked difference from the colon bacillus, to which it seems to be so closely allied. Inoculated on rabbits it was not fatal. Injected into the vagina of a pregnant cow, it caused slight discharge four or five days, but the calf was carried to full time 6½ months after the injection.

Bang found in aborting cows, between the womb and the foetal membranes, a considerable odorless liquid exudate of a gelatinoid appearance, and some pus cells. There was active catarrh of the mucus membrane of the womb which continued after abortion and often maintained the disease into the next pregnancy. In the exudate was an abundance of very small bacilli which stained deeply with aniline colors, excepting in a vacuole or mucleus which was less highly colored. This bacillus grew well in serum—glycerine bouillon, and more sparingly in serum—gelatineagar. In the latter it showed a remarkable peculiarity in growing with special luxuriance in different zones at two separate depths, beneath the surface, while there was an intervening clear space in which little or no growth took place. This preference for two different grades of abundance of atmospheric air and rejection of the intervening grade serves to identify the bacillus in a very striking manner. Injected into the vagina in two pregnant cows from healthy herds it produced abortion in one on the 21st day, and death of the calf without prompt abortion in the second. It also induced uterine catarrh and abortion in ewes, rabbits, guinea pigs and mares, when it was injected into the vagina. In several cases in which it was

injected under the skin or into the veins, it was later found in abundance in the interior of the womb and the foetal membranes and bowels of the fœtus. It can therefore live in the blood and pass from that into the womb to start its baneful work there.

Dr. V. A. Moore and the present writer have made a series of experiments at the New York State Veterinary College. We have found in the foetal membranes and uterine mucus, of a number of aborting cows, in different counties of the State, and situated widely apart from each other, a bacillus which in form and culture—experiments closely resembles bacillus coli communis. This was nearly always found in pure cultures, in a few cases only were other microbes found and these only such as are found in the healthy vagina. It was never found in the foetal membranes nor in the mucus of the womb in cows which had come to the period of parturition in healthy herds. It agreed in most respects with the bacillus found by Chester, but differed somewhat in fermentation tests. It differed also in being fatal to rabbits when inoculated on these animals. Injected into the vagina in three pregnant cows, it continued to live on its lining membrane, producing more or less catarrh and mucopurulent discharge in the different cases, yet all three carried their calves to the full time as judged by the forward condition of the teeth, one having calved on the 123d day, the second on the 167th and the third on the 190th after injection.

The investigations at the Delaware College Experiment Station and the New York State Veterinary College, indicate that the contagious abortion which was met with in the cows of these States is essentially different from the forms studied in Europe by Nocard and Bang respectively. The facts that the same germ was found alone or, exceptionally, along with the normal microbes of the healthy vagina in the womb of every aborting cow, and that it was not found in the healthy cow which had calved at full time, and that the generative passages were the seat of a catarrh, alike in the cows that aborted, and in those that were injected with cultures of the germ found in the womb of the aborting animal, is virtually all but conclusive, that this microbe is the essential cause of the abortion.

The fact that abortion has not so far occurred in the pregnant cows injected experimentally with the artificial cultures of this germ, only serves to show that under certain conditions the microbe operates slowly. In our cases the cows were dry during nearly the whole course of the experiment, and stood quietly in stalls, so that there was little accessory cause to assist in precipitating abortion. It is further worthy of note that in the form of abortion habitually prevalent in New York, it is the rule rather than the exception that the period of incubation often extends to the sixth month. In a recent case, which came under the observation of the present writer and in which the cow contracted the infection by the service of a bull in a neighboring aborting herd, the abortion took place at the sixth month of pregnancy. In our experimental cases, it was certain that the same bacillus, which was alone found in the aborting womb, and which was present there in great abundance remained present in the generative passages of the infected animals up to the time of parturition and thereafter.

It is worthy of notice that the recent bacteriological investigations of the disease in Europe shows that the pathogenic germ is present in large numbers in the digestive organs of the calf, that the new born calf can convey the disorder into a fresh herd (Sand) and that the viable calves of infected cows, are liable to die from intestinal disorders a few days after birth. Galtier, the Marquis de Poncius and Pry insist strongly on this. On a farm on the estate of the Marquis where abortion has prevailed for over twenty years, calves of infected cows show at birth or very shortly after symptoms of broncho-pneumonia and of a complication of nervous disorders. They are breathless, wheeze, discharge from the nose, cough, scour, have convulsions and other nervous troubles. A large proportion of such calves die; and their lungs are found in part red, consolidated and destitute of air, while the air tubes contain a mucu-purulent liquid. Lesions denoting inflammation of the pleural covering of the lungs of the liver and of the intestines are common.

This coincidence of a fatal disease in many of the surviving calves has not been specially noticed in the aborting herds in New York. Should it be found to be wanting or infrequent, it will establish still another distinction between the European abortions, as noticed by Nocard, Galtier, Sand, Bang and others, and the American type, as observed in Delaware and New York.

In investigating this subject it must be borne in mind that any catarrhal condition of the mucous membrane of the uterus hinders conception, and becomes a direct cause of abortion, and that the forms of invasion of the womb by pus-producing germs are as numerous as the number of different irritant germs that can live in the membrane. The question as to how many of these may induce contagious abortion is to be determined by the susceptibility of the membrane to the attack of each particular germ, and whether the latter can retain all its power of survival and virulence in passing from one animal to another. The presumption is, therefore, in favor of a variety of forms of contagious abortion, each due to its own specific microbe or microbes, rather than of a single unvarying type of the disease. It is the work of the future investigator to demonstrate the extent and nature of such variations, and to place the diagnosis and treatment of each on a substantial basis.

The indication that there are probably at least two forms of contagious abortion in cows raises the question whether both are to be found in our American herds, and, if not, whether there is not an urgent demand for such a rigid quarantine and inquiry into the condition of all imported cattle as will establish a reliable barrier against the more dangerous foreign disorder? No less important is it that we should recognize the presence of the more dangerous disease if it should already have a foothold in American herds, and trace its cause, nature and diagnostic symptoms, so that the treatment appropriate to each individual outbreak may be promptly and intelligently applied. The tens of thousands of dollars lost every year through the prevalence of contagious abortions in the dairy herds of New York would justify a liberal outlay to establish our knowledge and practice on a rational and scientific foundation. In Europe the loss on each aborting cow is set at from $12 to $25 per annum.

DO THE SAME ANIMALS ABORT SEVERAL YEARS IN SUCCESSION?

The question of persistent abortion, year after year, by the same cow, is one of far-reaching importance. If a first contagious abortion entails a second, a third, a fourth and a fifth in the same animal, in as many successive years, then manifestly her preservation is a mere squandering of money, apart from the danger of her transmitting the disease to other and healthy animals. If, however, on the other hand she herself fails to abort the second or the third year, yet if she continues to carry in her generative passages the germs of the malady, as potent as ever for evil to other pregnant cows, her preservation in her present condition is a hidden source of the infection, that can still spread from her to all new and susceptible cows which may be added to the herd.

It was long supposed that repeated abortion for an indefinite number of successive years was inevitable in the animal which was once infected. There is no doubt that certain cases give color to this belief. In an organ so nervously susceptible as the womb, there is always a tendency to repeat the abortion under the stimulus of a new pregnancy and the gradual distension and development of the uterine walls. Yet statistics show that this only applies to a small proportion of cows, and these the most excitable and nervous. The tendency toward insusceptibility to the deleterious action of the germ, which still may be present, is in the cow greater as a rule than the disposition toward a nervous increase of the susceptibility. The difficulty in reaching a conclusion on this point depends on the fact that stock owners very commonly dispose of aborting cows, and as the freshly brought cows are sooner or later attacked, it is too confidently assumed that the old cows, too, would have aborted had they been retained. Many years ago observant New York dairymen had noticed that the same cow rarely aborted over three years in succession and the majority not over two. Quite recently the owner of a large herd, who had had much experience with the disease, assured me that the rule was that a cow did not

abort a second time. The continuance of abortion in the herd was mainly among newly purchased cows, and others that had not been previously attacked. The same is measurably true of the European abortions. Nocard says that after three to five years there is an acquired immunity. Only heifers and the cows that have been recently brought in abort. Penberthy says that in case of repeated abortion in the same cow, the calf is carried longer each successive year until it comes to its full term. Sand, in his symposium of the experience of Danish veterinarians, says it is quite exceptional that a cow should continue to abort, but outbreaks of abortion disappear spontaneously if no new cows are brought in.

In the main this is endorsed by the experience of Bang. In a herd of 200 head, in the course of several years, 83 aborted in their first pregnancy, and of these only 20 aborted in the second, and 7 failed to breed. Counting these latter as having aborted, this amounted to less than one-third, while over two-thirds of the cows which aborted the previous year carried the calf to full time. In the herd only 30 aborted for two successive years and only 6 for three years running.

Paulsen quotes the case of a herd of 16, seven of which were sent for service to a bull in an aborting herd. All seven aborted; five at ten weeks, one at three months and one at four and one-half months before the normal period of parturition. One of the seven was sold, but the remaining six all went full time in the following year.

Mörck records the case of a herd of 16 cows, of which the majority aborted in the same year. The owner disposed of all the aborting animals and replaced them by others freshly purchased. Next year the new stock aborted, together with some of the cows that had been held over. He continued this course for eight years without any improvement, and then decided to keep the aborting cows, as well as the others. In two years the affection disappeared from the herd.

Such small herds, in which all become early infected, and in which there are not yearly additions of young animals in their

first pregnancy, nor the opportunity for a continuous extension into new animals that have previously escaped infection, furnish a better opportunity than do the larger herds, to trace the acquirement of artificial immunity.

Prevention and Treatment.— Admitting the frequency of acquired insusceptibility, we have to guard more against the infection of new animals than against repetition of abortion in the same cows. To protect the new stock against infection, however, it becomes necessary to purge from the infection, all cows which still harbor the germ in their generative passages, though they do not themselves any longer abort. It becomes also necessary to guard against infection through stalls, bulls, etc., from such infected, but no longer aborting, cows.

Upon the following points there can be no dispute:

1st. The cow which shows symptoms of abortion should at once be removed from the others, and her stall, including the gutter and drain leading from it, thoroughly disinfected.

2d. Every cow which has aborted should be instantly removed from the stable into a separate building, and her stall, with its gutter and drains, thoroughly disinfected.

3d. The aborted foetus, with its membranes, should be at once removed and burned or boiled, or deeply buried after it has been sprinkled with chloride of lime or other active disinfectant.

4th. The manure from the infected stable should be taken into an enclosure to which no cows have access, and freely watered with a solution of sulphate of copper. (One ounce in one quart of rain water.)

5th. The cow which has aborted, and those standing on each side of her, or the cow threatened with abortion, and those standing on each side of her, should have the external generative organs, the adjacent parts of the thigh and the whole length of the tail sponged every morning with the solution of one ounce of sulphate of copper in one quart of water.

6th. The cow that has aborted, or is suspected of abortion, and which has been isolated from the herd in a special stable, should have its stall carefully cleaned, scraped and watered daily with

the sulphate of copper solution. Her manure and urine must be carefully disinfected, as provided for above.

7th. In case that more than one animal has aborted in a herd or stable, it is desirable to sponge the external generative organs, hips and tails of the whole herd daily with the sulphate of copper solution, and to disinfect the hind part of the stalls, the gutter and the drains every morning, as prescribed above.

8th. Further to prevent the introduction of the infection into a herd, all newly purchased cows should be put at first in a separate quarantine stable, and subjected to daily disinfection of the external parts, and the stalls. As each cow comes in at full time, and without any indication of disease, she may be transferred to the stable occupied by the general herd.

9th. In purchasing a bull the greatest care must be taken to see that he comes from an absolutely sound herd, and that he had not been allowed to serve cows from a herd where abortion exists. It is a safe precaution to wash his sheath with the disinfectant liquid and to inject it freely with the same before beginning to use him in the herd. He should be allowed to serve no cows from outside the herd, unless it can be shown that they are from herds that are absolutely free from abortion.

By a rigid application of the above measures the extension of contagious abortion in a herd can be certainly prevented, and the rule being that the majority do not abort a second time the disease can in this way be got rid of.

It must be borne in mind, however, that in an infected herd there will always be a certain number of pregnant animals, in which the germ is already lodged deeply in the vagina and even in the womb, and these measures cannot prevent the occurrence of abortion in their cases. There is also the danger in a certain limited number of these, which have a tendency to abort a second time, that the germ will continue to live throughout the following year in the interior of the womb, and not only cause another abortion in the individual cow, but start the infection anew in other members of the herd.

There is some danger of such survival even in a cow which has become herself immune so that she will carry her calf to full time and yet infect other susceptible cows which may be exposed more or less directly to her discharges. It is for such cases that medication by the mouth and injections into the vagina or womb have been resorted to.

Among medicines used to check abortion by acting on the general system are viburnum prunifolium and potassium chlorate, which can hardly be upheld as disinfectants, but act only on the nervous system or on the general health. Carbolic acid one of the latest fads, is employed on the other hand with the intent of checking the propagation of the contagious element. Diluted in water so as to be nonirritating it has been injected daily under the skin, for a length of time and with alleged good results. It is noticeable however, that when the good effects have been apparently most constant the animals have at the same time been subjected to very careful and continuous external disinfection, which in itself is amply sufficient to account for the favorable outcome. When it has been employed apart from such external applications, the results have been much less favorable. Thirty-seven Danish veterinarins employed it in ninety-two separate herds, with results that were apparently good in forty-seven cases, doubtful in twenty, and negative in twenty-five. Thirteen other veterinaries who have employed it extensively report the results as doubtful or negative. It is not surprising that a majority of these practitioners abandoned a method which in theory must be looked on as unpromising and which proved so uncertain in actual practice.

11th. The other resort is a priori more promising consisting as it does in the application of a disinfectant, to the infected mucus membrane of the generative organs. The two agents most in use are carbolic acid and mercuric chloride.

Carbolic acid which is the less dangerous agent is prepared by adding one troy ounce and a half of the acid to a gallon of water, together with a troy ounce of carbonate of soda. This is injected daily for a week, through a large syringe, or an elastic

rubber tube introduced into the passage and having a funnel inserted in its outer end, which is carried two feet higher than the root of the tail. A quart may be employed at each injection and it should be used milk warm.

The mercuric chloride the more poisonous of the two agents, is used in a solution of one drachm to the gallon of water, to which is added a drachm of hydrochloric acid. This is used milk warm in the same way as the carbolic solution. This is very corrosive as well as poisonous and must be kept in a wooden vessel, safely locked up from man or animals.

The writer has used such injections in aborting animals and herds, and at the same time with the daily disinfection of the external parts of the generative organs, the stalls, gutters, drains and manure, and with perfect success where it could be thoroughly carried out.

It is subject to the serious objection that it causes active straining when the injection is administered, and if this becomes extreme, it may create apprehension, that it will precipitate an abortion rather than obviate it. This has led Nocard and others to abandon the injections and to rely altogether on external disinfectants. For pregnant animals this is to be commended as the disinfectant cannot penetrate and disinfect, an already infected womb, and is therefore not likely to prevent an abortion when the germ has already gained that cavity. In the cow that has just aborted on the other hand, the danger of injury from this cause is reduced to the minimum and the disinfectant injection thrown into the depth of the womb itself, offers the only hope of a speedy disinfection of that cavity. The external application merely prevents the access of new germs from without, while those that are within are left to be destroyed by the unaided action of the lining membrane of the womb. That this action is usually slow is illustrated by the fact that the abortion germs habitually live for a great length of time in the vagina and womb, before producing abortion, and that they often continue to live there much longer unless preventive measures are resorted to. In the animal which has aborted some time before

and which is still unimpregnated, injections are equally commendable. It may not be admissible in this case to introduce the liquid into the womb, but even if limited to the vagina, the resulting disinfection is highly advantageous in cutting off this source of renewed infection for the uterus, and placing the organ in a much more favorable position for the destruction of the bacilli which it contains.

CONCLUSION.

In conclusion it may be stated that this subject still offers an extension field for profitable investigation, and that we should not rest satisfied with the partial knowledge already attained, but push our inquiries in new directions, when there is a good prospect of securing the means of a fuller, more perfect and more easily available control of this great source of loss to our dairy interests. The form or forms of contagious abortion in our home herds should be fully investigated and the conditions of the life and propagation of the germs more definitely determined, and the same should be secured for other forms which may not as yet be indigenous to the United States, but which are likely to be introduced through the medium of importations. Our dairy industry is one of the most important of our sources of income, and a moderate outlay for an investigation which will render that safer and more remunerative, or which will protect it against threatened dangers from without, must prove an important measure of national economy.

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PHYSIOLOGICAL VARIATIONS.

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In biological study we generally identify form with function, but sometimes their relations are vague, at others they wholly elude our perception, yet we usually assume the interdependence of anatomy and physiology.

We are not clear as to which is cause and which is effect, although as a rule we attribute physiological or pathological phenomena to structural differences, but it seems more probable that the reverse is true, and that anatomical peculiarities are due to physiological variations. We attribute the form of the ruminant to rumination, not rumination to the complexity of the stomach; carnivorous teeth to the devouring of flesh, and not flesh-eating to the form of teeth, yet, knowing the functions of these organs, we may refer an animal to a given order by their form. In animal physiology, whether normal or pathological, it is important that in so far as possible we comprehend each function in its true light and not erroneously ascribe physiological peculiarities to irrelevant details in structure.

It is a current practice in medicine, not wholly unknown in other professions, to attempt to answer all questions propounded with some plausible theory, which, if it does not explain, serves at least to cover up some very rugged points, and so we attempt frequently to explain the occurrence of physiological or pathological phenomena by some imaginary or irrelevant anatomical detail. A good example of this recklessness in formulating theories is the common explanation given of the occurrence of roaring in horses by attributing it, and its usual seat on the left side, to the disposition of the left recurrent laryngeal nerve; but when we recall that other domestic animals, in none of which roaring occurs, have the same disposition of the nerve, it is evident that we must look further for an explanation, and conclude that the existence of roaring in horses is dependent rather upon some physiological variation than anatomical peculiarity. Closely allied in many respects is the peculiar equine malady, which,

in a paper presented to this Association in 1894, I termed *enzootic spasm of the larynx*—a disease attributed by me at an earlier date to the eating of frozen maize, by others to feeding on Indian vetches, and by still others to poisoning through the use for drinking of mill-tailing waters. None of the causes proposed offer any explanation for the limitation of the disease to solipeds and the impunity with which other animals may eat frozen maize or Indian vetches or drink the tailings from smelters or ore-mills.

Of greater interest, because of its more general prevalence and consequent economic importance, is the disease of solipeds known as "heaves," a malady which has led to many theories and controversies but to no reliable conclusion as to its nature.

Putting these three together, they constitute an isolated group of diseases confined to solipeds and almost wholly to horses, mysterious in nature and without prototypes in other animals unless we except the asthma of man; yet we find no anatomical reason why solipeds should monopolize to the exclusion of other animals the entire group of functional respiratory affections.

Another well-marked peculiarity of the horse which is very lightly but ineffectually explained is the rarity of vomition, which it is said is due to the peculiar palate or the arrangement of the cardiac orifice of the stomach, so that he *cannot* vomit. We can tie a dog's œsophagus so he cannot vomit, but if we give him emetin it will still induce nausea, and in the production of nausea rests the real difference between the two animals, for any of us of moderate experience knows full well that if a horse be nauseated he can vomit readily.

I have seen a horse sit on his haunches like a dog and vomit until certainly his stomach was well emptied, yet there seemed little amiss except the nausea, after the subsidence of which he appeared as well as usual. Again, I have been frightened to see the free vomition of decomposing food in a severe case of indigestion, in which the vomit was mixed with considerable quantities of blood, yet the vomition had apparently the salutary effect observed so often in dog and man.

We must then search for the rarity of vomition in the horse in the peculiar difficulty with which he becomes nauseated.

Each animal offers specific affections, which are as well marked and as closely defined by specific boundaries as those above mentioned, and their existence in or confinement to a given species cannot at present be explained except by some physiological peculiarity of the animal.

The semiology of disease is frequently very much modified by the functional peculiarities of the patient.

In the ordinary pneumonia of the horse the patient cannot lie down comfortably, while in the same disease the cow habitually assumes the recumbent posture with ease. Of greater physiological interest are the more essential symptoms produced by diseases alike essentially in etiology and nature, yet causing the most diverse effects upon the patient according to age, species, or other factors.

Indigestion in the horse produces pain and delirium; in the foal, pain and diarrhœa; in the cow, coma and paralysis; in the infant or puppy, convulsions; and while we may recognize certain differences in food or other causative factors, they do not fully account for the great variations of essential symptoms.

In the realm of transmissible affections we find a still more interesting example in rabies or hydrophobia, the cardinal symptoms of which in nearly all animals is intense fear, coupled with discordant efforts to protect self from imaginary foes, but we find this symptom strangely perverted in some animals. The sheep may attack rather tamely by butting, but its most marked symptom of the malady is nymphomania, although normally its sexual desires are ephemeral and never so intense in health as is observed in the bitch and cat, and strangely, too, the fact that the ewe is pregnant is no bar against the nymphomania.

The rabid pig shows no nymphomania, and, as observed by me, no attempt whatever at attack or defense, but rather tries by backing and whirling to get away from the imaginary foe.

Individual peculiarities are constantly observed in disease, and may prove interesting or confusing. I recall a case of colo-cæcal impaction in a mare where the ordinary extreme extension of the limbs as if to urinate was replaced by the animal standing on its hind legs with its forefeet propped up on a nail-tie at the side of the stall, about five feet from the floor, thereby accomplishing in a measure the ordinary effect as to position in a grotesque manner.

In the physiological action of drugs and medicinal agents we find great variations which we must constantly take into account, and not accept the behavior of a given agent in one animal as conclusive proof that it will act likewise in all others. Such an assumption frequently leads us to conclusions no less dangerous than false. In a paper presented to this Association last year[1] I had occasion to

[1] Therapeutics of Colic.

refer to the variation in the action of opium and morphine in the horse and man, being in the former, when given in large doses, a violent and dangerous excitant to the spinal cord and respiratory apparatus, while in man it generally poisons by producing coma; consequently if we accept the normal physiological action of the drug in man as our guide for its use in the horse, after passing a given dose which may have a slight anodyne action, we quickly reach an excitant effect, which is rapidly and dangerously intensified by increased doses, leading many veterinarians to destroy the lives of their patients in the vain attempt to reproduce the action of this drug as seen in man. But opium is by no means the only medicinal agent offering perplexing differences in action, which we can only attribute to physiological peculiarities in the various animals. This is particularly noticeable in our use of cathartics. Magnesium sulphate, so prompt and in many respects effectual in man and several of our domesticated animals, when uncombined is not only ineffectual in cattle, but under certain conditions seems rather to retard than encourage intestinal activity, although if combined with a liberal amount of sodium chloride it becomes quite efficient. We explain this deviation from the normal action of magnesium sulphate by saying that the addition of the sodium chloride increases the animal's thirst and thereby proves a valuable adjunct to the magnesium; but this does not explain why the adjunct is essential in cattle and uncalled for in man. Similiar variations hold true in the action of other purgatives, which, while not so well marked, lead us to elect certain members of the entire group for each of the various species of domesticated animals and even for the various ages and breeds.

The physiological peculiarities of animals which determine the pathogenic power of living organisms offer an interesting field for investigation. One phase of this topic was suggested but not considered in a paper presented to this Association in 1894 upon the "Influence of Climate and other Environments upon the Character and Distribution of Disease," in which it was noted that many diseases possess well-defined geographical limits depending upon climatic or other influences. These influences evidently may act either subjectively or objectively; they may weaken or destroy the pathogenic organism or increase or decrease the resisting power of the animal to be attacked, which latter we must attribute to variations in the functional peculiarities due to environment—changes which must be constantly taken into account in every department of our

science. A disease which is a serious scourge in crowded quarters or under certain climatic influences may prove utterly insignificant under other conditions.

In the paper above mentioned it was noted that the physiological conditions of range horses at high altitudes in our Western States rendered glanders among them an almost non-contagious affection, with a marked tendency in those affected to recover spontaneously. At the same time animals kept in bad stables in the adjacent valleys and put to hard work contract glanders readily and severely.

Since other diseases show equal variations under changed climatic conditions, a study of these become essential not only in veterinary sanitary science, but also in the daily work of the private veterinarian.

We fully recognize that animals strengthened or depressed by food, labor, or housing possess varying powers of resisting the encroachment of disease, and that these same influences enable or disable an animal to undergo a given surgical operation.

In transmissible diseases the powers of species or individuals to resist the inroads of the pathogenic organism form one of our most intensely interesting studies. It is noticeable that but few of these affections have even a moderately wide specific habitat.

Anthrax, tuberculosis, rabies, and glanders present the widest range of possible existence, while most transmissible affections are confined to a genus or species. Thus Texas-fever, bovine pleuro-pneumonia, equine pleuro-pneumonia, equine distemper, canine distemper, hog-cholera, chicken-cholera, and a long list of such maladies have closely defined specific limits except possibly under artificial conditions. The functional causes which render one species vulnerable, another immune to given diseases, are already producing profound results in the domain of medicine, although the fundamental facts are not yet discovered. We fully recognize the value of physiological resistance to disease in the selection of animals for the artificial production of immunizing or curative agents. It is greatly to be hoped that the present intense activity in biological study will yet discover the causes of physiological immunity of one species against diseases to which another is highly vulnerable.

The crowning achievement of modern medicine is the artificial production of immunity against a disease to which the individual is ordinarily liable. While immunity as a result of the invasion of disease in a tangible form has long been recognized, it has been only recently that this immunization has been intelligently produced

without the advent of the disease. The production of immunity by disease has always been regarded as a very grave danger in many diseases, few patients passing safely through the ordeal necessary to the physiological change, while the immunization without the presence of the actual disease has greatly lessened the danger and also has taught us undeniably, what many believed before the recent discoveries, that many patients acquire immunity against a given disease without exhibiting any of the cardinal symptoms of the affection, or, we might say, the patient has been invaded by a pathogenic organism which has produced the physiological changes we call immunity without producing the functional discord which we term disease.

Furthermore, we may consider the possibility of the production of physiological variations which may become hereditary, resulting in permanent, specific immunity, by which all the individuals of a species may become invulnerable to a given disease—a proposition which, although at first apparently untenable, yet seems quite as plausible as the great anatomical changes which we generally admit have taken place during a long series of generations. The multiplicity of pathogenic organisms besetting us on every hand would render higher animal life impossible but for very general specific immunity. We can realize the importance of the physiological peculiarities which cause this immunity by observing the seriousness of the already mentioned group of affections having a wide specific range of habitat, chiefly tuberculosis, anthrax, glanders, and rabies. All are much dreaded and constitute the most difficult group of affections to control or eradicate, largely because of their ill-defined specific limits, although none of them is exceedingly highly contagious, and each seems to have its climatic limitations.

The vast number of highly contagious and fatal maladies, such as hog-cholera or chicken-cholera, were they not confined to certain species by what we conceive to be physiological immunity, would inevitably sweep higher animal life out of existence, thus rendering immunity against a large proportion of pathogenic organisms in each animal a necessary safeguard to the survival of its species. In what manner the physiological changes are brought about by which specific or hereditary immunity ensues, little is known; but it seems not improbable that it is largely the same, but in a more gradual manner, as the individual immunity produced by the first attack of disease.

It appears that constant contact with certain pathogenic organisms

begets gradual immunity without intervention of that train of phenomena we designate disease, so that while an animal is kept in unsanitary environments which weaken the normal resisting powers of the body, it affords, by habit, protection against those forms of disease the causes of which are constantly present and acting, so that an animal subjected to unsanitary conditions tends to acquire more or less immunity against these, but the reduced general vitality renders the system all the more vulnerable to new foes, as in case of the people in the slums of great cities, whose systems become inured to the dangers which are constant and withstand them in an extraordinary degree, but the advent of new ones, like typhus or cholera, causes appalling destruction.

Reptiles and batrachians revel among miasms and pathogenic organisms which would prove deadly to many other forms of animal life; and carnivorous and especially scavenger animals wax strong upon food teeming with decomposition-bacteria and their products, which would prove of serious consequence if ingested by others.

It is not unreasonable to believe that the physiological modifications induced by environment fixes in a degree the ability of various animals to undergo successfully certain physical injuries or surgical operations, which, possessing certain definite characters and being more or less uniform, offer special facilities for comparison. We find functional characters so greatly varying that operations which can be borne with impunity by one species of animal can be undertaken in others only with considerable danger; in one animal aseptic precautions are needful and imperative, in another they are wholly unnecessary. Take, as an example, operations affecting the body-cavity. In man or horse these can only be undertaken under the most scrupulous aseptic precautions; in the common fowl we cut in between the ribs without asepsis, spread the ribs apart, remove the testicle in sight, then probably break into an air-sac or two, break through the mesentery, search for awhile for the other testicle, then roll the bird over, cut between the ribs on the other side, secure and remove the remaining testicle, and turn the bird loose with a large opening passing entirely through the body from side to side, through the abdominal cavity, with considerable blood-coagula left without removal, and the air-sacs punctured so that essentially the lungs have been opened. The patient misses no food, loses no flesh, and apparently pays no heed to the ordeal through which he has passed. In other words, the chicken possesses immunity against wound-infections to a high degree. Several domestic animals possess a degree

of immunity against wound-infection only slightly inferior to the fowl. The dog is especially resistant in this respect, so that the bitch is habitually spayed in utter disregard of aseptic precautions, sanitary surroundings, or surgical neatness, yet successfully and safely. Yet some writers advise great nicety in asepsis, anæsthesia, etc., in this operation, although their reasons for such careful technique do not appear; but we would not have it thought we counsel abandon and recklessness in the matter. We do hold, however, that it is our good fortune that complete asepsis is not imperative when we consider the difficulty with which it may be applied, and there is scant need for insisting upon so much labor to produce it for an operation not worth the trouble. Others say it is cruel to spay a bitch without first producing anæsthesia, but anæsthesia is more dangerous to the life of the bitch than the operation. Still another writer insists that the operation at best is cruel, but spaying a bitch causes less suffering and loss of flesh than giving birth to a single litter of puppies or even to going through a single period of œstrum; and it is consequently wrong to gauge our operations on dogs by the results of similar procedures on animals possessing quite different physiological properties.

While we as veterinarians must recognize the importance of asepsis in our handling of surgical or accidental wounds, we are not to be discouraged nor prevented from carrying out an operation because of the impracticability of applying aseptic or antiseptic rules with that exactness demanded in human surgery.

Wishing to try the economic value of spaying range mares, upon looking up the literature relating thereto it was found that one of my colleagues stipulated that the vagina should be scrupulously disinfected on the day prior to the operation, then again upon the day of operation, and that the procedure itself should be carried out under the most exacting rules: all blood-clots removed from the vagina, the vaginal incision sutured, and every possible precaution taken against wound-infection. My subjects, however, were wild mares, which must be lassoed and tied securely head and foot for the disinfection, released for a day, and then caught again for redisinfection and operation. The excitement of catching and the rough handling would offset the imperfect disinfection, and, moreover, the wild mares were not worth the expense. It was essential that a more practical method should be adopted, and consequently they were roped and forced into a branding chute, secured in a standing position, the feces removed from the rectum by an assistant; about

one quart of a 1 : 5000 or less sublimate solution was thrown into the vagina, the incision quickly made, the ovaries taken away with the ecraseur, the blood-clots in the vagina left there, the vaginal incision left open, and the wild mares released ; and, to my astonishment, it was found that the animals withstood the operation better than yearling colts do castration.

We also recognize physiological variations in breeds and individuals, and find that we must gauge our remedy and dose, must undertake or decline an operation, and must be guided in our prognosis by the functional peculiarities of the patient before us. In every department of our profession we need to closely follow the physiological peculiarities of our wards and to intelligently base our actions upon a practical study of their normal functions, and not to rely upon what we term general or classic physiology, which is made up of a series of deductions drawn from facts gleaned indiscriminately from the whole field of animal life and not always having a general application.

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ATRESIA OF THE RIGHT POSTERIOR NARIS IN A MARE.

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The subject, a small brown mare, aged four years, used for delivery by a retail butcher, had been recently purchased without a reliable history as to the date of the advent of respiratory difficulty, but it was said that she had suffered from an increasing dyspnœa for about one year.

As this is the date at which the animal would ordinarily be first put to work, in all probability the difficulty in breathing was merely not noticed until brought out prominently by labor.

Presented at the free clinic, October 9, 1896, it was observed that rapid driving caused severe dyspnœa and roaring, while at rest the respiratory sounds were normal, but the ingress and egress of air were confined wholly to the left nostril, the right being functionless.

Inspection revealed no facial deformity, no definite dulness nor want of resonance over any of the facial sinuses, no nasal discharge or odor, no cough, and no abnormality upon manual exploration of the mouth and pharynx.

The symptoms observed, in conjunction with the history of a gradually developing dyspnœa of a year's duration, led us to believe that we had to deal with a neoplasm encroaching upon the right nasal conduit.

On the following day the animal was cast and two exploratory openings made—one into the inferior maxillary sinus, near the fang of the fourth molar; the other against the median line of the face, on a level with the lower margin of orbits. No abnormality could be discovered from either, except that the turbinated bones, normal in structure, approached more nearly to the septum nasi than usual, until an attempt was made to pass a sound from the second opening through the posterior naris, which was found impossible.

After a prolonged effort and the use of as great force as seemed prudent the sound suddenly passed through into the pharynx, and

upon its withdrawal a small quantity of air passed out through the right nostril, and blood passed from the nostrils into the pharynx, leading us to the erroneous conclusion that we had encountered a neoplasm and had passed the sound alongside between it and the bony walls of the posterior naris.

We were unable to learn the form, character, size, or attachments of the obstruction; concluded that a successful operation was impossible, and abandoned further attempts at surgical interference.

It was noticed that the patient now forced some air through the right nostril, and continued to do so; but its significance was not understood, and believing restoration of the animal to usefulness impossible, she was destroyed on November 26th and an autopsy made

No neoplasm was found, but across the right posterior naris, continuous with the nasal mucosa on the outer and the pharyngeal mucosa on the inner side, was a thin, hymen-like membrane, stretching like a drum-head between the palatine, ethmoid, and vomer bones, completely occluding the opening except for a small rent in its centre, oval in form, three-fourths by one-half inch in diameter, the result of the accidental opening made with the sound at the time of our exploratory operation. The occluded right posterior naris measured transversely from vomer to palatine bone seven-eighths of an inch, while the left measured one and one-half inches. The tissues were all healthy and showed no evidence of pre-existing disease of any kind, indicating clearly that the abnormality was congenital.

The cause of the deformity must be referred to early embryonic life after the endoderm of the ovum had, by infolding, produced the primitive intestine, ending anteriorly in the pharynx, in front of which the olfactory pits develop, but are for a time separated from the pharynx by a thin septum, which, becoming obliterated, brings about the opening known as the posterior naris.

In this individual the septum had become obliterated on the left side, while on the right the development had become arrested, the septum, as a result, persisting.

The bibliography relating to this form of arrested development is exceedingly limited.

Through the aid of my colleague, Dr. Law, I have been enabled to find the record of one similar case by Prof. Gamgee (*Our Domestic Animals in Health and Disease*, p. 622), who relates an instance observed by Hering in 1842, in which a filly, two and one-half years old, was presented to Prof. Hering for advice regarding a severe dyspnœa and roaring, which had been observed for a year.

No evidence of tumor or other neoplasm or pathological condition could be found to explain the roaring, except that it was found that the right nostril was impervious to air and that a flexible sound could not be passed into the pharynx through the right nasal passage. Failing, like me, to make a diagnosis, the filly was destroyed, and, as in our own case, the autopsy revealed a thin septum stretched across and completely closing the right posterior naris, and, in full accord with our views in this case, he considered the cause an arrest in development in the early embryonic stage, by which the septum, at that time normal, failed to undergo that obliteration which should naturally follow.

Perhaps the deformity is more common than records would indicate, and it would seem not unlikely that in some cases both septa persist, leading, especially in foals, to early death, owing to the difficulty it has in breathing through the mouth; hence it would seem well for veterinarians to have in mind the possibility of the occurrence of this peculiar form of arrested development, its diagnosis and treatment.

The diagnosis offers no great difficulty to the veterinarian cognizant of the occurrence of such an abnormality. We observe:

a. Dyspnœa and roaring.

b. Imperviousness of the affected passage to air.

c. The absence of any neoplasm or tumors in the nasal passages or sinuses, or of dental or other diseases leading to suppuration or other changes capable of interfering with respiration.

d. The nasal passage and nostril free; though, perhaps owing to non-use, the turbinate bones are nearer to the nasal septum than ordinarily observed.

e. The posterior naris closed, as shown by the impossibility of passing a sound into the pharynx, but permitting the sound to pass over the naris until the ethmoid bone is reached.

f. The Polansky-Schindelka rhino-laryngoscope would enable one to observe the actual condition of the deformed part.

The Gunther Eustachian catheter should prove an excellent sounding instrument, or in its absence an effective sound of similar form could be improvised—that is, a rod about one-fourth of an inch in diameter, with a slight curve anteriorly, commencing about two inches from the anterior end. With this sound measure the distance from the superior angle of the nostril to the lachrymal angle of the orbit, which will about equal the distance from the inner border of the nostril to the centre of the posterior naris.

Passing the sound along the floor of the nasal chamber, it will

be found that when it reaches the point indicated by the measurement, instead of passing *downward* into the pharynx, it glides *upward* for a distance of two or three inches and stops against the ethmoid bone. A common flexible horse-catheter would answer the purpose well, but perhaps not so well as the metallic sound.

The treatment is exceedingly simple, and consists merely in pushing the curved end of the metallic sound through the membranous partition, and then enlarging the opening, or an opening may be made alongside of the septum nasi, just below the frontal sinuses, and an ordinary pair of curved forceps of sufficient length passed downward between the septum or vomer, striking the persistent membrane almost at right angles and rendering its rupture and laceration to any degree desired readily accomplished. The removal of the lacerated portions would be quite unnecessary.

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AZOTURIA, WITH STRAIN AND ATROPHY OF THE GREAT DORSAL MUSCLES IN A MARE.

By W. L. Williams, V. S., Prof. Surgery and Obstetrics, New York State Veterinary College.

It is not unusual to meet with contusions, strains and fractures as a result of casting horses for operations, and at times we have had occasion to observe tympanitic colic after tedious, cramped confinement, but we have neither observed nor found recorded, among these accidents, the disease we know as azoturia or hæmoglobinuria.

The subject was a common-bred mare, aged eight years, used for light farm work and well kept by a very gentle owner. She was worked regularly during the summer, but quite irregularly during the winter.

For three years she had suffered from mild double navicular disease, which became more continuous and pronounced about September, 1896, on which account she was presented at the college clinic on Feb. 16, this year, for operation.

On the 15th, the patient was led about nine miles and on the 16th completed her journey to the college, a further distance of six miles, and was placed in the college hospital at 2 P. M. She was in robust health and high condition, without excessive fatness, and having travelled the entire distance at a walk to the halter, she arrived wholly without fatigue. On the evening of the 16th and morning of the 17th, she was fed sparingly on wheat bran and hay, after which she was led a short distance to a smith for shoeing, was allowed no food at noon, and was cast for neurotomy at 2 P. M. of the same day. She was cast with ordinary sidelines and surcingle, all four feet being securely fastened to the surcingle rings, well up on the sides of the chest, the fore feet being alternately released for operating.

Low neurotomy was performed on both fore feet by a student who had not previously attempted the operation, the work being as promptly and skillfully performed as could be expected. The patient struggled violently and persistently throughout and upon her release got up without assistance or unusual effort and walked to her stall, apparently weak and stiff from her confinement, but without suggestion of grave injury. At 10 P. M. she was down but apparently comfortable and was left for the night without suspicion of anything unusual.

On the morning of the 18th, it required the aid of two men to assist her to her feet. She was then with difficulty walked to an adjacent stall and placed in slings. Examination showed the two ileo-spinali muscles, as well as the gluteals, much swollen, hard and tense, the left side being most severely affected. The urine was abundant and of a dark chocolote color characteristic of azoturia.

As is usual in severe or moderate cases of azoturia, the slings could not be borne, and the patient was lowered to the floor and well bedded. Becoming uneasy again after some three hours, she was once more lifted to her feet and placed in slings, and was then found able to remain in them, bearing her chief weight on the feet. She was accordingly left in the slings until the morning of the 19th, when she had so far recovered from the attack that the slings were discontinued and the patient got up and down at will. She ate fairly well and drank a moderate quantity of water. The tumefaction of the muscles appeared to decrease for a time without medication, but soon began to increase.

On Feb. 22d the great dorsal muscles were enormously swollen, hard, tender, hot, standing up above the spinal column, the course of which was marked by a furrow, the affected muscles standing out clearly from neighboring structures, thus marking as clearly and with as great detail the exact area of the dorsalis muscles on each side from withers to the loins as could be done by a dissection, the tumefaction extending backward and including to some extent the gluteal muscles also, and to a lesser

degree the posterior muscles of the thigh (semi-membranosis and semi-tendonosis), rendering the patient quite stiff in her movements and causing her temperature to rise to a maximum of 103.4° F.

On the 23d there was little change in condition except some œdematous swelling about the sternum and in the limbs, the œdematous condition involving the operative wounds, causing the bandage to be saturated with serosity, but not otherwise affecting them unfavorably.

Up to this date in conformity with my usual practice, no medication had been applied; but to relieve the complications present, diuretics were ordered internally and an anodyne liniment to the affected muscles.

On the 24th there was a general improvement, the muscles were less hard, the swelling decreasing and all seemed so favorable that the medication was relaxed, and on the following day, the improvement continuing, it was discontinued and out-door exercise permitted for a short time.

On the 26th, while the general condition of the patient was quite satisfactory, it was seen that the great dorsal muscles were commencing to waste rapidly, and having seen two previous cases of severe strain of these, due to casting with side-lines, both of which, without the coincidence of azoturia, resulted in extreme atrophy, it was at once concluded that in this patient, too, the atrophy would prove rapid and complete.

On the 27th the atrophy continued with great rapidity and on the following day it was seen that the left gluteals were involved also to a moderate degree.

On March 1st, the atrophy of the great dorsals was complete, giving the appearance of the subcutaneous excision of the entire muscles from withers to loins, leaving a deep, wide furrow on either side of the spinal column, the dorsal spines of which stood up sharply.

The general improvement was rapid, so that on March 3d, she was discharged convalescent, the operative wounds entirely healed without scar, the appetite and general health good and

without apparent weakness from the extreme muscular atrophy, and travelled home, a distance of fifteen miles, without difficulty.

While this case points clearly to the possibility of azoturia as a casting accident, it suggests perhaps with equal force the possible coincident production of both a strain and azoturia of the same muscles, tending to confusion in diagnosis and treatment. We have no differential symptoms of a local character between the two, although the one is admittedly a local affection, the other a constitutional malady, the exact character of which is an unsolved problem. In fact, the only grounds for the opinion that the two coexisted in this case are that we had present the pathognomonic constitutional symptoms of azoturia, with the history of violent struggles of the animal under conditions which had previously in our experience produced severe strain of the great dorsal muscles without azoturia, the eventual results of which were parallel in all cases.

The tumefaction of the great dorsal muscles and their later severe atrophy belong quite as much to the one as to the other of the two affections.

It has been already noted that immediately prior to casting the patient for the operation she had been sparingly fed and had had very slight exercise, each of which tended to obviate azoturia, and would generally have sufficed, and left us in a somewhat difficult position to explain the occurrence of the disease. Later we discovered that for a period of 20 hours prior to casting she had been deprived of water, an element not generally reckoned with in the etiology of azoturia, although we have ventured to suggest a parallel line of thought in a prior article in the REVIEW.* Therein and elsewhere we have held that azoturia is due to certain definite conditions having for their antecedents well determined historical data following each other in an unvarying sequence.

a. A sound animal with exalted nutritive powers not drawn upon by disease, pregnancy, rapid growth or senile wasting.

* "Pathology of Azoturia," etc., AM. VET. REV., Vol. XIV., p. 172

b An abundant nitrogenous diet without overfeeding to the extent of impairing digestion, absorption or nutrition.

c A period of labor which instead of producing poverty or emaciation shall bring about a vigorous and robust state of the entire body, especially of the nutritive and muscular systems.

d A *brief* cessation from labor with more or less completely enforced rest extending over a period of one to ten or possibly rarely more days.

e An abrupt termination of the brief period of enforced idleness by labor or other severe exertion, during the first one, two or rarely more hours of which the susceptibility to the malady is manifest, after which the equilibrium of the system is restored and the possibility of producing azoturia ceases.

In studying the effects upon the physiological state of the animal induced by the environments in the sequence related we find in :

a A system prepared for intense nutritive activity, reaching beyond the general requirements of the body.

b A diet fitted to produce a high state of nutrition, especially a highly nitrogenous blood supply, abundant in quantity and quality.

c The period of labor intensifies, per necessity, the nutritive activity which is met by the abundant food supply, increasing the amount of the red blood cells and other nitrogenous constituents of the blood, muscles and other tissues without augmenting in a like degree the water of the blood and other nutritive fluids ; a state in the highest sense physiological and capable of indefinite maintenance.

d The nutritive functions stimulated by the preceding conditions attain a high degree of perfection and acquire what we may term a momentum capable of continuation during a *short* but not *long* period of rest with the usual rations, resulting in the accumulation in the blood of an unnecessary amount of nutritive material, rendering that fluid still richer in solids and comparatively poorer in water, producing a state which we may term qualitative plethora, and which, though perhaps perfectly

physiological, can only be temporarily maintained, but during which period a comparatively slight disturbance of the equilibrium may bring about results of a grave pathological character.

e Finally the period of sudden exertion causes through the arousing of sweat and other secretions a rapid withdrawal of water from the blood, while at the same time solid products of tissue waste are promptly thrown into its current, the two factors combined serving to render it so far sub-normal in its relative amount of water that the resultant density makes it impossible for the blood current to pass normally through the capillaries, leading rapidly to blood stasis, extravasation, necrosis of the blood, breaking down of the red blood cells, their resorption and eventually excretion by the kidneys—hæmoglobinuria.

It has been experimentally shown that a muscle at work requires about 75 per cent. more blood than the same organ at rest, and we constantly observe that locomotory muscular contractions offer the greatest physiological resistance to the blood current, increasing the number and force of the heart's beats. We should then expect to and do find that the blood stasis occurs in the capillaries of the great muscles of locomotion, with engorgement of arteries and capillaries, extravasation of blood into the muscular tissue, with tumefaction, pain and eventually paralysis of the part, followed in many instances by atrophy of the affected muscles.

If this line of reasoning be correct, we would anticipate the greatest changes in those muscles most violently exercised, hence in azoturia produced by locomotion we should expect the disease to exert its chief force upon the gluteals and the ilio-patellar group of muscles, while in a casting accident like that related the latter group would wholly escape, while the great dorsal muscles would prove the salient point of attack, the gluteals and posterior femuro-tibial group participating.

In the typical case of azoturia one of the most evident symptoms is the knuckling over of the posterior metatarso-phalangeal

articulations, due chiefly if not wholly to the grave lesions in the ilio-patellar muscles, but in the case related, the affection of these parts being wanting, this symptom too was absent. This case affords special support to our view of the pathology of the disease, since although the patient had been somewhat restricted in diet and very gently exercised, which would under ordinary conditions have prevented the disease, yet these were more than counterbalanced by the extreme water starvation which should, if our contention be true, be even more effectual in the production of the disease than the slight and brief decrease in the amount of food and the very deficient exercise immediately prior to the casting in its prevention.

These circumstances lead us to believe that the causing of animals in a state bordering on azoturia to drink freely of water just prior to their first labor after a period of rest would tend to prevent in many cases the advent of the disease, and emphasizes the importance of relying in our treatment of azoturia, as we have long done, chiefly upon inducing the animal to consume as much water as is possible, and lends force to the belief which we have for some years held, but not tested, that the most efficient and rational treatment for the disease in its initial stages consists of the intra-venous injection of water or a ½ or 1 per cent. solution of sodium chloride.

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THE SPAYING OF MARES.

By W. L. Williams, V.S.,
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The emasculation of domesticated animals, destroying their sexual power and instinct, has been freely practised for centuries, the reasons therefor varying with different species of animals, in different countries, and under diversified conditions. Most of these operations are so common that in many cases they are performed chiefly by stockowners, while others are left almost if not wholly to skilled veterinarians.

The spaying of mares has long been practised in Continental Europe, but there appears to be little modern literature upon the subject available to the American veterinarian. The earlier method of operating, which is now very rarely practised, consisted in making an incision in the flank of sufficient size to admit the operator's hand, through which the ovaries were removed. Later Charlier introduced the method of spaying the larger animals through the vagina, greatly decreasing the extent of the surgical wound, which, being protected by the vulvo-vaginal canal, rendered external influences less potent; and, added to this the more recent introduction of antiseptic and aseptic surgery, the spaying of mares has been included in the list of operations which may be undertaken by the veterinarian with every confidence in a successful issue.

In spite of the great advances in recent years in abdominal surgery, the spaying of mares has in this country been surrounded by an unwarranted fear, of such a degree that but few veterinarians attempt it, apparently believing the operation one of special difficulty and danger. As a consequence we have but few veterinarians that have spayed any considerable number of mares consecutively or in a manner which would serve as even a moderate test of the danger to the animal, or even give the surgeon the desired amount of experimental knowledge of the operation.

During my official connection as veterinarian with the Montana Agricultural Experiment Station a favorable opportunity occurred

in the summer of 1896 for testing the effect of the operation on a larger scale than usual, and the experiment was consequently undertaken. Aside from the test as to the danger to the animal, and possible additional data as to the proper details of the operation, it was hoped to secure additional knowledge as to the economic value of the procedure as related to the rearing and handling of horses. Among the benefits hoped for were: First, increased docility of the animal; second, the prevention of the œstrum with the attendant nervousness, weakness, and repulsiveness; third, a safe mode of control in breeding.

As a general rule, it may be stated that emasculation of an animal increases its docility. This is more markedly true of the female than of the male. Sexual appetite being practically constant in the male, castration does not uniformly obliterate it, especially if the animal has not been emasculated until of adult age or near it; while in the female, with periodical sexual desire only, the obliteration of these periods of œstrum almost invariably destroys sexual instinct and renders the subject in the fullest sense neuter.

This end gained, we have secured the second class of benefits by doing away with the repulsive features of œstrum, avoiding at the same time the accompanying nervousness, irritability, and more or less incapacity for work.

The third incentive for the operation—that of the control or prevention of breeding—has a special application in Montana and other Rocky Mountain States, in that spaying is practically the only available method which can be employed to prevent unguarded mares from becoming pregnant not so much by valuable sires as by a low grade of mongrel horses, the progeny of which can but prove worthless. While Montana and perhaps most other Western States have laws against stallions running at large, they are quite inoperative, the ranges being constantly infested with mongrel stallions of the lowest type, so that mares are liable to impregnation at any time—this fact constituting one of the important causes of very marked degeneration of range-horses during the past few years. Moreover, there is a vast surplus of these semi-wild mongrel horses far beyond the demands of commerce, unsalable, and a serious nuisance to the ranges by consuming food which might otherwise be used by animals of distinct value. The operation would, then, if generally applied, soon reduce this class of horse to the legitimate number demanded by our commerce. Besides, it seems that in all probability the mare-gelding will prove more desirable than the gelding, the mares being generally of finer finish, are free from the

repulsive and annoying accumulations of filth in the sheath of the penis of the gelding, and are cleaner in the stall, owing to the direction in which the urine is voided—the gelding unavoidably soiling his bedding, while the mare need not do so.

The instruments used in the operation consisted of a Reed injecting pump, vaginal dilator, like that used for spaying cows; a twenty-two inch Chassaignac écraseur with guarded ratchets, which could be worked within the vagina, and a concealed knife. The mares were in two lots, which we shall designate numerically. Lot No. 1 consisted of sixteen mares, of which one was a very weak, thin, half-starved mongrel three-year-old filly, procured but a day or two before operation, and fifteen grade French draught-mares, four to six years old, four of which were broken to saddle or harness, while eleven were range-mares, handled slightly as weanlings, since which time they had ranged unhandled and unguarded among the mountains. Except the three-year-old all were in prime condition, and presumably not pregnant. None of them were known to be vicious except one of the broken mares, which was at times balky, probably during the œstral periods. None of the animals were at the time receiving grain, and only the five broken mares had at any time been fed on grain, but had lived exclusively on the range, except as weanlings, they had had an allowance of hay.

The five broken mares were taken from the range on the evening of June 24, 1896, and placed in a bare corral with running water, where they could drink at will; and the eleven unbroken animals were placed in the same corral the following morning after a sharp drive of ten miles from their usual feeding-grounds. The five broken mares with five unbroken were operated upon on the evening of June 25th, and the remaining six on the morning of the 26th. The mares were led into a chute used for branding cattle, the unbroken ones having been caught with the lasso. They were secured by means of a halter to a post in front of the chute; bars were placed beneath the chest and abdomen and the tail drawn directly upward and made fast to a cross-beam, thus preventing the animal from lying down. The hind feet were secured by means of ropes to posts in front of and behind the animal, so that it could neither kick nor extend the feet forward in an attempt to lie down, while the possibility of rearing was prevented by tying a rope across the back. Two or three quarts of tepid water were then thrown into the rectum and the feces removed by an assistant; the vulva and perineum were washed and the vagina filled with a 1:5000 solution of corro-

sive sublimate; the hands and arms washed in the same, and the instruments disinfected.

The vaginal tensor was then introduced with the hand, the prolongation fixed in the mouth of the uterus, the walls of the vagina rendered tense, the concealed knife carried into the vagina, opened, and an incision about one inch long made at the end of the vagina just above the mouth of the uterus, after which the knife was removed. The hand being again brought into the vagina, one or two fingers were pushed through the incision, followed by the other fingers of the hand in cone shape, the walls readily giving way and the entire hand pushed into the abdominal cavity. The écraseur was then introduced, guarded by the hand. By following the uterus, lying immediately beneath the incision, the cornua were soon reached, leading from it at almost right angles, soon ending, to be continued by the ligament of attachment, in which the ovary was readily and unmistakably found at a distance of two or four inches from the blunt end of the cornua. The chain of the écraseur was then placed over the ovary, and, holding the instrument and ovary securely with one hand, the instrument was tightened with the other, the ovary quickly crushed off, and carried out along with the écraseur. The crushing off of the ovary was practically the only step in which there was evidence of any considerable degree of pain, and this was not nearly so severe, judging by the struggles of the animal, as is seen in the castration of horses. The second ovary was removed in the same manner. Very little bleeding followed the operation. The animals were released without further procedure, and all confined in a meadow convenient for observation.

They were inspected twice daily on June 26th, 27th, 28th, and 29th, as closely as practicable with wild mares. There was some slight straining shown by most of the mares immediately after their release, and nearly all were noted lying down quietly. None of them at any time, so far as observed, showed any signs of severe pain, not nearly so severe as is commonly seen after the castration of stallions. The three-year-old mare, which as before stated, was in poor condition, in fact not fit to undergo an operation, seemed stiff and dull, but continued to graze daily. No discharge from the vagina was observed and no symptoms appeared to create alarm, and by the 29th she seemed somewhat improved. She was the first animal operated upon in the number, and my first operation on a mare, and in addition to her unfit condition, the emptying of her rectum was neglected, presuming that without grain the feces would be soft and pultaceous, but instead the rectum proved quite full of

rather firm fecal matter, and in cutting upward toward it, and the vagina of the mare being *very much* thinner than that of the cow, the cut was made too deep and almost penetrated the rectum, a complication which probably did much to interfere with her recovery. Of the other mares none appeared to suffer noticeably, except one animal lay down much of the time, but when approached would jump to her feet, trot quickly away and commence to graze. Two or three others showed slight stiffness for twenty-four to forty-eight hours, but not sufficient to lead the ordinary observer to note anything amiss. When approached they all trotted briskly away, all grazed regularly, and apparently did not emaciate or lose weight.

In operating it was found that one mare was about seven months pregnant, and it was expected that she would abort, but she seemed to still be carrying her foal safely at the date of our last observation, and continued as well as the others, but later she lost her foal, whether by abortion or otherwise, is not known.

Lot No. 2 consisted of six farm-bred mares, aged from two to ten years, all broken, and at the time of operation were not being fed on grain; they were taken directly from the pasture for the operation, which was conducted the same as in Lot 1, on the 12th of August, 1896.

One of this lot, an aged mare with foal at her side, was apparently unwell for some weeks, while the others showed only slight effects of the operation for three or four days, and on September 8th, twenty-seven days after operating, the owner reported all completely recovered. The owner of Lot 1 reported all well on August 3d.

Of the twenty-two mares in the two lots, but twenty were successfully spayed, errors in two cases having necessitated the abandonment of the operation at an early stage. Both were fillies, one two, the other four years old. In these cases the incision through the vaginal walls was made too far posteriorly, behind the peritoneum, and instead of entering the abdomen led into the rectum. As the peritoneal sac remained intact, no serious harm came from the error, except that the operation was of necessity abandoned. The causes of the error were at least two, the vagina of the mare being very much thinner than that of the cow, to which the writer was accustomed; the incision was carried too far before danger was anticipated; but of greater importance was the essential difference in the relations between the vagina and rectum in the mare and cow. These have not, we believe, been distinctly pointed out, though probably other operators have noted the difference. The peritoneal covering on the superior surface of the vagina is not so extensive in

the mare as in the cow, the rectum and vagina being in immediate contact until near the uterus, thus leaving but a very contracted field for operating, especially in fillies which have not bred. Moreover, it has been noted by others that manual exploration of the vagina of the mare causes it to dilate by becoming "erected," in which case it appears that the free part of the vagina assumes a position at right angles to the rectum. If, then, we follow the directions generally given, and make an incision in the vaginal walls two inches *posteriorly* to the os, we cut not into the peritoneal cavity, but into the rectum. Our error indicates clearly that the proper place for the incision is *above* and *immediately against* the os uteri, and that this is especially necessary in young fillies, in which the available field for operating is very contracted, yet ample, if these directions be followed.

Some writers direct that the vaginal incision should be complete, the entire thickness of the vaginal wall being cut through, and state that tearing through the peritoneal layer with the fingers should in no case be attempted, even though the knife need be introduced several times, declaring that tearing through this membrane is exceedingly liable to induce grave suppuration between the walls of the vagina and rectum. In a large proportion of the twenty cases above noted we cut only through the mucous and muscular coats, and completed the opening by tearing through the peritoneum with the fingers, yet, so far as we know, had no untoward results therefrom. It seems far more likely that the abscesses related by others were due rather to the same error we have recorded above, that is cutting either behind the peritoneum or just at its passage from the rectum to the vagina. Evidently such an error would tend to that result. We found it much easier to rupture the peritoneal coat of the mare with the fingers than it is in the cow.

The difficulty which some record, of a partial paralysis of the rectum after the operation, leading to retention of the feces and necessitating enemata, was not observed except in a minor degree with the two fillies in which our errors were made and the rectum wounded.

On the whole, our preparations were in some respects quite imperfect, especially the opportunities for careful asepsis. True, the animals were in the main very vigorous and in a climate not so prone to induce septic infection as many other regions; but, on the other hand, we feel that the disadvantages in our arrangements quite fully offset these.

We were forced to conclude from our experiment that the spaying

of mares is neither difficult nor dangerous, and with some experience in castrating stallions under similar conditions we consider the spaying of mares the safer operation of the two. In each we open the abdominal cavity, in the stallion almost directly through the inguinal ring, in the mare quite indirectly through the long vagina.

With this experience before us, we have not hesitated in our free clinics at the New York State Veterinary College to spay mares as occasion requires. We recently had occasion to spay a vicious mare, dangerous to her driver on account of violent kicking, especially when in œstrum. Presented at the free clinic for operation, after a morning's work on a heavy ice wagon, without food, she was secured by placing her in an ordinary sling, her tail being secured upward to the sling's pulley, the hind feet secured forward and backward to rings placed in the walls, and the operation carried out under good aseptic precautions, without incident, except that the vulvo-vaginal walls contracted so forcibly about my arms as to render the operation difficult and cause my arms to ache painfully for seven or eight hours, although the operation was of but fifteen or twenty minutes' duration. The powerful contractions of the vulva constituted good evidence of an exalted perverted sexual excitability evidently closely related to the viciousness of the patient. The animal was immediately led home, a distance of one mile, fed moderately and exercised gently daily. The owner reported that her appetite was constantly good, she showed no stiffness or disinclination to move, or other signs of suffering from the effects of the operation, and after a period of ten days returned to her accustomed work, where she has since continued more docile and in better flesh than prior to emasculation.

It seems to us, therefore, that the spaying of mares is an operation quite warranted in general veterinary practice, less dangerous and painful than the castration of horses, and far less difficult than many of our more common operations. A more general introduction of the practice would greatly increase the value of many mares, especially those which are vicious, nervous, or repulsive during œstrum. Many of these are now bred in order to render them docile, a practice which is most unfortunate, as such mares are not at all suitable for breeding-purposes, tending strongly to reproduce their vicious characters in their progeny. In addition to the suggestions naturally emanating from our experience as here recorded, we may note that the method we have casually named, of securing mares for this operation by means of the ordinary horse-sling, is a most effectual and convenient one. With the tail secured upward to the

sling-pulley, it is not only out of the way, but is of great value in preventing the animal from sitting down in the sling, while with the hind feet secure both backward and forward the mare can neither kick nor extend the members forward under the belly, but with tail and hind feet secure, and with the aid of the sling, the mare is readily kept in a posture favorable for operating.

INVOLUNTARY TWITCHING OF THE HEAD RELIEVED BY TRIFACIAL NEUROTOMY

By W. L. Williams.

From Journal of Comparative Medicine and Veterinary Archives. July, 1897. Pp. 426-428.

We occasionally meet with a peculiar disease, habit, or vice in the horse which apparently no one has attempted to describe, though doubtless observed by almost every veterinarian of experience, the chief symptoms of which are involuntary shaking or twitching of the head and rubbing of nose and lips against convenient objects.

In our personal experience the abnormality has been chiefly noted in young horses of marked vigor of constitution, highly fed, and well kept, with but moderate or very light work. It develops gradually and has attained well-fixed characters before the owner has noticed what seems to him an hallucination or vice. The animal more or less frequently gives the head a sudden jerk or shake, as though tormented by insects, though no cause for the movement is discernible. The owner or driver will attribute the difficulty to an irritation of the bit, something about the nose or the ears, but a close study indicates that the movements are not subject to the control of the animal.

The symptoms are in evidence chiefly in winter in mild cases. They disappear with the advent of warm weather, to reappear upon the return of winter, while in severe cases the symptoms are much ameliorated during the warmer months. The symptoms are aggravated when the animal is ridden or driven, but continue in the stall. As the head is twitched there is generally considerable motion of the muzzle, the upper lip being moved as though irritated, and if a convenient obstacle is near the lip is rubbed in a hurried and quite intense way, as though to dislodge an insect.

A close inspection fails to reveal any anatomical lesion to explain the symptoms. Owners have prevailed upon us to clip the hairs from within the concha, under the belief that possibly these irritated the external ear ; other owners have applied anodynes to the part. We have

examined the teeth in detail, hoping there to discover the cause, and smoothed these; but the mystery of the abnormality, its cause and nature, remained unsolved, and no guesses served to cure or alleviate the difficulty.

During the college year of 1896–'97 three cases of this kind were presented at our free clinics, two of which were turned away as mysteries after one of them had had his teeth carefully examined and smoothed with the rasp.

The third case presented was a well-bred, vigorous young gelding of fine style and action, but rendered comparatively worthless by the constant twitching of his head whether in harness or stall, accompanied by intense rubbing of the upper lip on the manger, pole or other convenient object.

By wearing a small net, in general character like an ordinary cord fly-net, large enough to cover the nostrils and upper lip, the owner found he would go fairly well in harness, but the presence of the net was sufficient to attract attention and prevented his sale. The owner, a dealer, was consequently anxious to have some remedy applied which would render the animal agreeable to drive and saleable. He was fully persuaded that the difficulty lay in an irritation or hyperæsthesia of the upper lip, and when assured that sensation in this could be almost wholly destoyed by sectioning the supermaxillary branch of the trifacial, the owner promptly insisted that the operation be tried, which was accordingly done.

The horse was cast, the hair shaved from the skin covering the infraorbital foramen, and a solution of cocaine injected upon the nerve. The skin was thoroughly disinfected and an incision about three-quarters of an inch long made directly over the course of the nerve, laying it bare. It was then cut through at the infraorbital foramen, after which a section of the nerve about three-quarters of an inch, was dissected out and excised, the wound dressed with iodoform, sutured with catgut, the operation repeated alike on both sides of the head, the patient released, and placed in a box.

The cocaine failed in its mission, and the operation proved one of the most painful we have ever witnessed. After the operation the symptoms were greatly exaggerated, the animal being quite frantic. throwing his head violently and recoiling suddenly whenever his nose came in contact with the stall, feed-box or hay-rack. In a few hours he was, with some difficulty, hitched with his mate and driven home, a distance of twenty miles, though found exceedingly difficult to manage, a serious disaster being narrowly averted at one time.

Soon after reaching home the exalted nervousness subsided and marked improvement soon set in, the wounds healed aseptically, and within a few days the patient had recovered from both operation and malady and was driving normally, and continues sound now after about four months.

The results of this operation indicate a peripheral neurosis of the trifacial, and go far to contradict the belief that it is a habit or vice.

The operation itself is exceedingly simple and easy, but it is the most painful in which we have ever engaged, and should be undertaken, it seems to us, only under complete general anæsthesia. With proper precautions aseptic healing should be readily attained.

No attempt should be made to work the animal for some days after treatment. Our success seems to indicate that the operation is a radical cure for the malady and capable of fully restoring the usefulness of this class of animals.

TRAUMATIC PERICARDITIS IN A COW; RECOVERY.

By W. L. Williams.

From Journal of Comparative Medicine and Veterinary Archives. July, 1897. P. 451.

There is usually so little to be hoped for in traumatic precarditis in the cow that the following observation seems worthy of record:

The patient was a valuable Jersey cow in vigorous health and in milk.

About January, 1896, I was called to attend her for tympany, which was moderate and accompanied by painful respirations with grunting during expiration, and a general stiffness and disinclination to move, which led us to suspect the ingestion of a pointed foreign body. The rumen was punctured, saline purgatives with carminatives administered, followed by apparent recovery.

About four weeks later I was recalled, and found the patient dull, stiff, disinclined to move, feverish, dry muzzle, inappetence, tumultuous pulse, intermittent and irregular, with abnormal pericardial sounds. The sypmtoms were referred to the prior attack of tympany, and traumatic pericarditis diagnosed and an unfavorable prognosis given. Small doses of digitalis were administered three times daily, and within a few days distinct improvement was noted, the appetite returned, febrile symptoms abated, the movements became more free, and the milk flow became normal.

Early in June following I was requested to examine the animal, and found a prominent tumor beneath and to the right of the sternum in the anterior angle of the space formed by the ensiform and last costal cartilages. The tumor was fluctuating, and, being punctured, about one pint of grayish, very fetid pus escaped. Exploring the cavity with the finger, two irregular pieces of bone were found, the larger being one-half by three-quarter inches, and sharp. Both were apparently originally of the same piece, and in texture and general appearance had apparently come from a rib or vertebræ, probably from a porterhouse steak, the bone of which had found its way into the kitchen scraps which were fed habitually to the cow.

It seems quite certain that a bone had in this manner been swallowed by the cow, induced the indigestion first noted, penetrated the rumen, passing forward to the right posterior surface of the pericardium, causing pericarditis, after which it travelled to the right and downward, emerging partly decomposed at the point described.

LUXATION OF THE METACARPO-PHALANGEAL ARTICULATION IN A HORSE.

By W. L. Williams.

From Journal of Comparative Medicine and Veterinary Archives. July, 1897. P. 452.

The comparative rarity of luxation without fracture in horse renders the following case of interest :

The patient was a common, medium-sized animal, used for wholesale grocery delivery, and while being driven at a trot over a railway crossing caught her left forefoot between the railroad rail and the crossing board, causing her to fall heavily forward on the imprisoned member.

The foot was pried loose with a crowbar. The animal got up, when the driver noticed that the fetlock-joint was out, but was readily replaced by him, and I was notified by telephone that the patient was on its way to our infirmary with its leg out of joint—"walking." On arrival at the infirmary the animal was walking comfortably without noticeable limping, no swelling or other injury about the joint being visible.

Picking up the leg and flexing it, the phalanges readily turned outward at a right angle to the metacarpus, and were as readily replaced. In other directions there appeared to be no abnormal mobility. The luxation and replacement caused no apparent pain or discomfort to the animal. She was walked home—a few blocks away—and the affected member placed in a firm plaster-of-Paris bandage reaching near to the carpus, which was allowed to remain for a week, the case going on without incident, and at the end of that time the bandage was removed and the animal returned to her accustomed work.

THREE CONSECUTIVE RECOVERIES FROM GLANDERS.

By W. L. Williams.

From the American Veterinary Review, July, 1897. Pp. 230-234.

In Bulletin No. 4 of the Montana Agricultural Experiment Station, largely reprinted in the *American Veterinary Review*, Vol. XIX, p. 6, we had occasion to note the possibility of recovery from glanders, either with or without treatment, and although such a possibility is in full accord with the veterinary science of to-day, the popular mind is still strongly imbued with the belief that this malady is uniformly and more or less rapidly fatal. Bearing upon this phase of the disease it is interesting to note the results of observations and experiments carried out upon three glandered horses, the property of Mr. Moses Decker, Bozeman, Mont.

Two of these animals are noted in Bul. No. 4, as Nos. 6 and 7, in table on page 104, but without special detail, that presented being unfortunately vitiated by typographical errors on page 105, where in 4th line from top "No. 5" should read "No. 6" and in 6th line, same page, "No. 5" should read "No. 7." These two animals, Nos. 6 and 7, were a pair of well-bred, light road-mares, used almost exclusively for light road work and were constantly together.

In Dec., 1893, I inspected two horses on Mr. Decker's premises which had been kept with Nos. 6 and 7 and which were clearly affected with glanders, the septum nasi of one of these being shown in Fig. VII, Bul. 4.

On this trip to inspect the above glandered horses, Nos, 6 and 7 were used for driving, and it was noted that No. 7 appeared somewhat out of health, with harsh, rough coat, but nothing definite could be detected. About a month later, however, she developed symptoms of acute, nasal glanders, discharging freely from both nostrils with the usual tumefaction of submaxillary lymphatic glands, leading the owner to conclude from his former experience that she was seriously glandered and must soon succumb, causing him to determine to destroy her without official inspection; but delaying action, the mare being isolated, she improved, regaining flesh and vigor until in March, 1894, she showed no

constitutional disturbance, but a personal inspection made revealed unmistakable evidence of glanders in the characteristic enlarged, nodular, painful and adherent submaxillary lymphatic glands, the glutinous discharge from the nostrils and the characteristic erodent ulcers upon the nasal partition. She continued to improve until on July 3, 1894, when she had apparently recovered except slight nodular swelling of the submaxillary lymphatic glands, at which time a test with mallein was undertaken, with the results as recorded in the table on page 104, Bul. 4 At the same time her mate, No. 7, and another mare, No. 8, both of which were apparently sound and believed to be so, were selected as "control" animals to act as a check upon the test on No. 6. The test revealed that No. 7 was, like No. 6, glandered, and this opinion was further demonstrated by succeeding mallein tests, while No. 8 withstood this and subsequent tests perfectly. Nos. 6 and 7 were safely isolated and kept for observation.

In the meantime Mr. Decker and his father had a considerable number of unbroken horses in a band some miles distant, but which had at an earlier date, been in contact with those killed in Dec., 1894, as well as Nos. 6 and 7 and some other horses killed on the farm for glanders, prior to my connection with the station. Some time in the fall of 1894 a deputy State Veterinarian killed two animals in this band on account of glanders, after which the remainder was brought back into the valley and wintered on the farm, when in the spring of 1895 a three-year-old developed the characteristic symptoms of glanders in mild form, and was promptly isolated from the healthy and placed in the enclosure with Nos. 6 and 7. We will designate this patient No. 9.

The three affected animals were allowed the liberty of a small pasture, were well supplied with good, nutritious food, had access to excellent running water, had reasonable shelter in very inclement weather and were not worked. No. 6 continued to improve from the time noted above, until to all outward appearance she was wholly recovered in March, 1895, and has so remained. No. 7 has at no time shown external evidence of the disease. During the present season, (1896) Nos. 6 and 7 have been put to ordinary work and have done it efficiently and vigorously. No. 8 continues to all appearances sound. No. 9 began improving shortly after inspection, March 22, 1895, and all physical signs of disease ceased during the same summer and have not returned.

Subsequent to the isolation of No 9, in March, 1895, no new cases have been developed upon the farm.

Placing no dependence upon physical signs alone in this disease, the animals in question were studied, by the aid of mallein, as closely as their distance from the station and my college duties would permit.

The subjoined tabular record of mallein tests indicates briefly the course of the disease.

No. of Animals.	Numbers are as in Bul. 4. Amount of mallein used, c.c.	Number of test.	Date of test.	Average temperature on day preceding the test.	Temperature at time of using mallein.	Highest temperature after injection.	No. of hours after injection when highest temperature was reached.	Increase of temperature in degree Centigrade.	Character of swelling at point of injection.
6	1.	1	July 3, 1894	38.3	37.7	40.3	10	2.0	Typical
	0.75	2	March 22, 1895	37.9	37.	40.5	12–30	2.6	"
	0.5	3	April 14, 1895	37.9	38.1	39.1	7	1.2	Absent
	0.7	4	July 31, 1895	------	37.9	38.8	12	.9	"
	0.8	5	June 6, 1896	38.4	37.5	39.	12	.6	"
7	1.	1	July 3, 1894	38.2	37.5	39.7	12	1.5	Typical
	0.75	2	March 22, 1895	37.7	38.4	40.3	6	2.6	"
	0.5	3	April 14, 1895	37.5	------	39.5	11	2.0	"
	0.7	4	July 21, 1895	------	37.5	38 9	11	1.4	Absent
	0.8	5	June 6, 1896	38.5	37.5	38.3	9–30	0.2	"
8	1.	1	July 3, 1894	38.1	37.3	38.4	12	0.3	"
	0.8	2	March 22, 1895	37.6	37.	37.8	8	0.2	"
9	0.8	1	March 22, 1895	38.4	39.	40.4	4	2.0	Typical
	0.7	2	July 21, 1895	------	38.3	40.1	12	1.8	"
	1.	4	June 6, 1896	38.6	37.4	39.1	11–30	.5	Absent

The mallein used for above experiments was furnished by the Bureau of Animal Industry. Nos. 6 and 7 were animals of about 900 lbs. weight, while Nos. 8 and 9 were of about 1200 lbs. weight, hence, 0.75 c.c. mallein for Nos. 6 and 7 equal 1 c.c. for Nos. 8 and 9, which is the average dose advised.

There is no positive evidence to show that the use of mallein exerted any curative effect in either of these animals, although various experimenters have concluded that it is capable of exerting a favorable influence upon the disease. It shows, however, that repeated use of mallein on an affected animal is at least not injurious. As stated in Bul. 4, the disease shows a strong tendency to spontaneous recovery in Montana if the animal be well kept, and not confined in stables except in very inclement weather.

The disappearance of the disease on the infected farm after killing some of the affected and isolating the others shows, too, that if due care is taken it is not extremely difficult to eradicate with the means at our command. By many laymen and even some veterinarians this affection is termed "catarrh" and ascribed to "taking cold," but when the diseased are isolated, the healthy animals cease to "take cold." The time required in which recovery from glanders may take place, the uncertainty of its taking place, the difficulty of knowing if an affected animal has really or only apparently recovered, the danger through accident to other animals or to man all militate strongly against any treatment yet proposed and render it impracticable, unsafe and only admissible as yet under peculiarly favorable surroundings as an interesting and valuable experiment, and generally leave the summary destruction of all affected animals the sole efficient means for its control or eradication.

INFECTIOUS ABORTION OF MARES.

By W. L. Williams.

From the American Veterinary Review, August, 1897. Pp. 303-305.

Infectious abortion as a distinct, specific malady has long been recognized among domesticated animals, and distinguished from greneral transmissable diseases which in the course of their attack may induce abortion of the pregnant females, as seen in hog cholera affecting pregnant cows, or the so-called "pink-eye" or epizootic (infectious) cellulitis of mares ; as well as the sometimes wholesale abortions reported from ergotized or other deleterious foods.

A brief *resume* of the literature upon the subject, as relating to the affection in mares, is given in connection with the records of some experimental work conducted by us, in the sixth and seventh annual reports of the Bureau of Animal Industry, Department of Agriculture, p. 449.

It is desired here to briefly record some observations made upon the control of the disease when once existing in a herd of pregnant mares. These observations were made in a herd of standard trotting and thoroughbred mares, the property of Mr. H., Bozeman, Mont.

In all, Mr. H. had, in November, 1895, twenty-five mares presumably pregnant. None of them worked except one grade draft mare, and all had apparently faultless care as to freedom, housing, feed and water. The first animal to abort was the grade draft mare used for general farm work, the abortion occurring in November, 1895, followed by somewhat widely separated abortions of three trotting mares, which led to our being consulted early in 1896, after which a close watch was kept, and on February 7th we were called to attend a young trotting mare which had apparently been in labor for some twelve to eighteen hours ; the fœtal membranes, considerably decomposed and discolored, were hanging from the vulva. The fœtus was found in a false position, which was readily corrected and the mare easily delivered. The fœtus was hairless, apparently of about eight months gestation. The afterbirth was removed, the uterus irrigated with carbolized water, and the patient comfortably housed. She apparently was doing well, ate moderately, and seemed safely on the road to recovery, until on the morning of the 9th she was

found dead in her stall. Autopsy revealed all organs except the generative apparently healthy. The uterus was enlarged, swollen and contained a large amount of a dirty, fœtid, watery excretion, while in the os and vagina were large masses of tough, fœtid, dirty, yellowish, croupous exudate.

During the ineffectual labor of the patient she was in company with some fifteen other pregnant mares. These were promptly removed to new quarters, and each mare received a vaginal injection of a solution of corrosive sublimate, 1-1000, to be followed daily with a sponging of the vulva, tail and surrounding parts with the same solution.

During the nights of February 26, 27 and 28 each, a mare aborted without having presented any signs of approaching trouble when left for the night, and the first intimation of the loss was the finding of the dead fœtuses in the stalls on the following mornings, the mares in each case being apparently well. The aborted mares were promptly removed to other premises, the fœtuses and membranes safely disposed of, the bedding cleared away and burned, the stalls fumigated by burning sulphur, and closed against other animals, and the sponging of the vulva and tail of the remaining pregnant mares renewed and carried out twice daily.

A few days later another mare, not known to have been in contact with those which had aborted, required aid in expelling a dead fœtus, and although carefully watched, developed severe metritis after forty-eight hours, which yielded to treatment.

The abortions ceased at this point, and in the course of a few weeks healthy foals were dropped as the remaining pregnant mares completed their periods of gestation.

The history of the outbreak, coupled with the symptoms, served to quite fully confirm the suspicion of infectious abortion.

The results of the antiseptic treatment point strongly to the belief held by most observers that the disease is essentially one of the fœtal membranes and fœtus, gaining access to these through the vulva and vagina, and serve to confirm results of a similar treatment carried out by several investigators in infectious abortions of cows and ewes. Although several mares aborted after the treatment had been applied, it is quite safe to assume that the infecting agent had already gained access to the fœtal membranes before the application of the treatment, which could not then be of any possible avail.

The disease having apparently ceased, Mr. H. again bred a part of his mares, and on December 29, 1896, reported that he had ten healthy foals of the previous spring, and that all mares bred seemed safely in foal, no abortions having occurred so far as discovered since those above recorded.

The origin of the affection in the herd of Mr. H. could not be clearly traced, but the malady seemed to be prevalent to some degree among mares on neighboring farms.

Mr. H. had on his premises also several mares which had come from the herd of Mr. D., where the disease had raged to such an extent, in the summer of 1891, that practically all mares had aborted.

In view of the success recorded by various observers with the plan of treatment here outlined and the confirmatory observations in this outbreak, it appears that when the disease exists among animals of sufficient value, its control and eradication may be undertaken with reasonable hope of success.

THE PARASITIC ICTERO-HAEMATURIA OF SHEEP.

By W. L. Williams.

From the American Veterinary Review, September, 1897. Pp. 377-380.

Under date of July 1st, 1895, was published under part of Bulletin No. 8, of the Montana Agricultural Experiment Station, some preliminary investigations regarding an outbreak of parasitic ictero-hæmaturia, or red water and jaundice of sheep, a disease heretofore described, so far as we know, only by Profs. Babes, of Roumania, and Bonome, of Italy. Since the publication of Bulletin No. 8, no outbreaks of the disease have been reported outside the area originally infected, and no reliable information has been gleaned to indicate the existence of this fatal malady anywhere in the United States, except in the Silver Bow and Deer Lodge Valley, near Butte, Mont. The subject is one of great scientific interest, and while of economic importance in a very limited area only, the possibility of other sheep ranges becoming similarly infested lends to the subject sufficient importance to warrant further study of its nature, and led me to keep as close watch as possible regarding its further continuance and spread.

The preliminary account of the disease, published in Bulletin No. 8, appeared in full in the *Veterinary Magazine* (Philadelphia), Vol. II, p. 497.

In the meantime the disease had abated, several owners sold the remnants of their herds, and nothing more was known of the malady until on May 28th, this year, a telegram was received from Mr. M., of Silver Bow, announcing its reappearance.

Proceeding to Silver Bow, on May 29th, it was learned that the disease, so far as known, was confined to the herd of Mr. M. His herd had wintered in the lower Silver Bow Valley, and had remained free from any epizootic disease until its removal, May 9th, to the foothills some three miles from its winter quarters, where, after a stay of about ten days, the disease appeared in a pronounced form, and sheep began dying in considerable numbers.

The herd was a mixed one of 1800 sheep, largely ewes, and 240 Angora goats. About the 18th or 19th of May, the sheep began dying at the rate of two to four daily, and continued through June. During the investigations of a year ago it was thought that one or two Angora goats had died of the disease, but in the present outbreak none of the 240 goats, which commingled freely with the sheep, showed any signs of the malady.

On May 30th post-mortem examinations were made on three affected animals, the results of which follow.

Case No. 1.—An aged Merino ewe, about 50 lbs. weight, weak and emaciated, was killed by bleeding. The subcutaneous connective tissue was of a pale, dirty-yellow color, the abdomen contained three or four ounces of dark colored serum, liver slightly enlarged, yellow, firm; gall bladder distended with dark-green bile, the connective tissues surrounding the gall bladder infiltrated with pale, dirty-brownish serum. Alimentary canal was moderately filled with food and offered nothing of note except a well-marked dirty-brown effusion along the smaller curvatures of omasum and abomasum. Kidneys enlarged, dark, soft, and on section much blackish urine exuded; bladder contained eight ounces dark-brown, semi-transparent urine. Uterus contained placental débris from recent parturition. Spleen small, globular, contracted, black on section. Lungs, normal, heart pale, flabby and empty. Facial sinuses contained six œstrus larvæ.

Case No. 2.—Grade Leicester ewe, 75 lbs., down, unable to rise. Conjunctivæ dirty-brown in color. Killed by bleeding. The blood flowed freely (black, thin and smeared on a glsss slide appeared to be dirty-brown in color, quite devoid of the usual red). Subcutaneous connective tissue dark, dirty-yellow. Omental and messnteric fat dirty, dark-yellowish brown, spleen small, firm, dark; the liver large, dark in color, the lobules yellow, the inter-lobular spaces filled with blood which gave a general dark color; the gall bladder contained about ten ounces dirty yellow bile, the bile duct contained five tænia fimbriata, each about six inches in length. Kidney slightly enlarged, dark-brown, moist in section, bladder empty. Pericardium contained half an ounce orange-colored serum, and showed numerous ecchymoses of the size of a pinhead; endocardium of left ventricle profusely ecchymosed, the discolorations being as much as one inch long by one-eighth of an inch wide, the heart tissues were flaccid and dirty pale-yellowish. The uterus contained placental débris of apparently three to four days standing. The facial sinuses contained four œstrus larvæ.

Case No. 3.—An aged Merino ewe, about 70 lbs. weight, with young lamb at side, in fair flesh, able to walk. Conjunctivæ and skin a dirty olive color. Was killed by bleeding and autopsy made at once. Blood moderate in amount, and of a dirty reddish-brown color. Subcutaneous connective tissues throughout the body, and to a lesser degree the mus-

cular tissues, were of a dirty leaden color, giving appearance of animal having been dead for a number of hours, with consequent post-mortem changes. There was, however, no abnormal odor, emphysema nor other evidences of decomposition. The alimentary tract was well filled with with food, the liver large, dark yellowish brown, very friable; the gall bladder moderately filled with yellow bile. The kidneys much enlarged, blue-black in color, œdematous, soft, on section very moist; bladder almost empty, urine dirty brown in color. Heart was pale and flaccid. The facial sinuses contained six œstrus larvæ.

Case No. 4.—A large yearling ewe, not pregnant, weak, moved with staggering gait, ears drooping, very œdematous, being two or three times their normal thickness. Conjunctivæ and skin had a bright lemon color. Patient killed by bleeding, blood scanty and feebly coagulable. Body well nourished and fat, all adipose and connective tissues throughout the body were of an intense lemon-yellow color, even the chordæ tendinæ of the heart partaking of the same color in a marked degree. Liver enlarged, bright yellow in color, lobules well marked, interlobular tissue being congested and dark red. The gall bladder contained 10 ounces of dark black-green bile, so dark as to appear perfectly black *en masse*. Kidneys slightly soft, moist; bladder contained one ounce of coffee-colored urine. Spleen small, contracted, hemispherical. Intestinal tract well filled, normal.

The above cases given in detail are essentially parallel to the results summarized in Bulletin No. 8 of the Montana Station with the notable exception of Case No. 3, in which the color of the tissues was very different, yet agreed in one important particular—the evidently grave disorganization of the blood cells. Case No. 4 exhibited, in a marked degree, a symptom, the œdema of the ears, which was only occasionally noted in the outbreak described in Bulletin No. 8, while in the above outbreak the Chinese shepherd usually noted the œdema of the ears as the first symptom of the disease, and, believing that slitting the ears in some way modified the disease, habitually practiced it and noted the escape from the wound of much of this anasarcous fluid. The face, too, was not infrequently swollen. An interesting observation was the fact that almost all affected animals were ewes which had but recently, two to six days prior, given birth to lambs, the ordeal of parturition apparently inducing a condition of the system which more readily permitted the ravages of the micro-parasite.

EXTREME LUXATION OF THE PATELLAE IN A FOAL.

By W. L. Williams.

From the American Veterinary Review, October, 1897. Pp. 444-453.

The subject, a filly of trotting breed, foaled May 27, 1897, was of good size and form, was able to stand and suck, and to the attendants appeared well.

The umbilical cord was ligated with a coarse, dirty string and the foal, with its dam, kept in a box stall.

It remained apparently well until May 31, when the stifles became much swollen and the foal was unable to stand without assistance.

At this time Dr. G. was called and found it unable to get up on its hind legs, while the two anterior limbs appeared normal. Each stifle was found inflamed, hot, tender and much swollen. The temperature was somewhat abnormal, though a definite record was not kept; the pulse was accelerated, and the general signs of moderate fever were present. The remnant of the umbilical cord was still present, well dessicated, and the ligature applied at birth was *in situ*. No evidence of infection existed at the umbilicus.

A diagnosis of umbilical infection was made and peroxide of hydrogen with salicylate of sodium administered internally and a stimulating liniment applied to the affected joints

With careful nursing and frequent assistance in reaching the dam's teat the foal continued to thrive generally, though unable to stand erect, but could attain a crouching attitude, erect in front, with complete flexion of the femoro-tibial articulations.

The general line of treatment was continued until July 2d, without material result; the dropsy of the joints had increased, and later with the subsidence of the inflammation had decreased and the synovial capsule had thickened.

At this date Professor Law and the writer found the patient unable to extend the femoro-tibial articulations, nor could they be fully extended

by the application of moderate force, while the two fore limbs tended to bend forward at the carpal joints, rendering difficult the maintenance of even the crouching position mentioned, for a sufficient period for the foal to suck. The hydrarthroses had extended far beyond the normal outline of the bursæ, especially outwards, extending over the external surfaces of the lower ends of femora and upper ends of tibiæ, the definite outline of the bursæ being lost externally and inferiorly in the general swelling and thickening of the parts. The enlargements were free from abnormal heat or tenderness.

The patellæ were displaced outwards and backwards and could be readily felt opposite the posterior border of external femoral condyles in immediate proximity to the posterior border of the tibiæ at a distance from the heads of these bones corresponding to the tibial points of attachment of the tibio-patellar ligaments.

The femoral trochleæ appeared to be normal, but the patelleæ could not be replaced in them by ordinary manipulation. Bed sores were present on the anterior faces of the fetlock joints.

The attitude of the foal when attempting to stand and the positions of the crural triceps group of muscles, especially the outlines of the rectus femoris and vastus externus and the location of the patella of left leg, are shown in Fig. 1. The muscles of the posterior limbs appeared normal in size and form, but the extreme displacement of the patellæ destroyed completely their power to extend the femoro-tibial articulation, and to a great degree the extension of the coxo-femoral and tibio-tarsal joints.

The foal was destroyed on July 3d by bleeding and the autopsy revealed the following abnormalities :

The extensor pedis tendon of the left anterior limb was ruptured between its communication with the lateral extensor of the phalanges and the annular carpal ligament within the bursa through which it glides over the carpus, the muscular end of the tendon being indirectly adherent to the carpal ligament through its fibrous sheath, while the distal end was free in the bursa, hæmorrhagic, smooth and enlarged. The direct or main tendon of the extensor pedis of the right anterior limb had parted within its carpal bursa, the superior end had become indistinguishably fused with the communicating division without leaving macroscopical traces of traumatism or inflammation. The ruptured end of the distal portion lay free within the bursa, enlarged, ecchymotic and smooth. The communicating branch of the tendon destined for the lateral extensor of the phalanges instead of consisting of one intact cord was teased out into numerous small fibres for a distance of two inches immediately in front of the carpus. The carpal bursa of the tendon appeared normal.

The vastus externus muscles (Fig. III *c*) were but slightly modified in direction ; the rectus femoris (Fig. III *b*) assumed an oblique direction downwards, outwards and backwards, while the vastus internus (Fig. III *a*) was stretched across the femur just above the lower articular

enlargement in an almost transverse direction, and seemed pale, thin and atrophied.

The three tibio-patellar and the capsular ligaments were indistinguishable, being represented by a thick fibrous capsule co-equal in extent with the enlarged parts.

The femoro-patellar synovial cavities, which had at an early date apparently been much more distended, contained now about one and one-half pints each of an apparently normal synovia, along with an almost equal volume of quite firm, semi-transparent, faintly greenish yellow synovial clot attached chiefly at the point of union between the capsular ligament and bone, and presenting centrally a free shredded margin three-fourths to one inch thick. (Figs. IV and V *b b*.)

The synovial clots were in places feebly adherent to the articular surface, which was normal, except that at the inferior part of the right femoral trochlea the external ridge had been worn away to a marked extent, denuding it of articular cartilage and subjacent osseous tissue (Figs. IV and V *d*.) As the patella could not at this time be brought in contact with the worn part, the destruction must have occurred at an early stage of the affection.

Well marked ecchymosis was present about the patella and patellar attachment of crural triceps as a result of the dragging of the misplaced parts upon contiguous tissues in the patient's efforts to extend the joint.

The extreme degree of luxation serves to explain and emphasize important facts in the etiology and history of closely allied or generically identical cases. The history and autopsy point to naval affection as the possible cause, this possibility being increased by the ligation of the umbilical cord, by which means the cut ends of two hollow vessels, the umbilical arteries, which would otherwise retract, were fixed in a position rendering their invasion probable, while the blood and liquids within the tissues of the cord were retained, serving as an excellent culture medium for putrefactive micro-organisms.

The patellar dislocations were evidently due to the hyper-secretion of synovia, which, distending the sacs, lifted the patellæ out of their grooves and beyond their retaining ridges when a combination of forces determined an outward luxation.

It has been held that external luxation of the patella is due to the lesser elevation of the external trochlear ridge, but this alone in such a case could not determine the direction of the dislocation nor even cause luxation at all. In this "floating" luxation the intra-articular pressure is alike in every direction, the walls of the capsule yielding at the various parts in inverse ratio to their strength, supplemented by other contiguous ligaments and tissues involved, so that the longer and thinner internal tibio-patellar ligament would yield more readily than the shorter, thicker and stronger external, thus guiding the patella outwards, which is further greatly favored by the disposition of the powerful long

vastus muscle, which through its attachment to the external ligament exerts an abducting power upon the patella which the abductors do not fully counterbalance upon this bone, hence we recognize as factors in outward luxation the lesser external ridge, the lesser strength of internal tibio-patellar ligament and the superior abducting power on the patella of the long vastus muscle.

The degree of luxation was evidently intensified by being bilateral so that any effort on the part of the patient to rise could not be centered on a sound limb, but must fall alike on each of two members, neither of which was capable of bearing weight except by an outward dragging upon the patella, which, buoyed out beyond its groove, was readily drawn from its normal location.

The case serves to illustrate, too, what the writer has long maintained, two generically different forms of patellar luxation, the "floating" form occurring almost wholly in young animals and caused chiefly by *navel infection* and *rickets*, in which, buoyed up beyond its groove by a hydrarthrosis, the patella tends to pass outward during flexion when the crural triceps and consequently the internal tibio-patellar ligament is relaxed and inwards during extension, thus denuding and in time wearin away the external ridge of the femoral trochlea ; and the traumatic or direct form, in which the luxation is suddenly produced by violence.

An important fact well emphasized in this case is the value of preventing in young animals the accumulation of sufficient synovia in the femoro-patellar articulation to buoy the patellâ outwards beyond the level of the trochlear ridges, which is to be accomplished by sufficiently frequent aspirations of the fluid in conjunction with the injection of appropriate remedies into the synovial sack.

CROUCHING ATTITUDE OF FOAL DUE TO DISPLACEMENT OF THE TWO PATELLÆ.

a Crural triceps muscles. *b* Left patella.

FIG. II.—EXTERNAL VIEW OF RIGHT STIFLE.

a Superior end of femur.
b Transverse section of tibia near its middle.
c c Distended synovial capsule.
d Patella
e e Long vastus muscle.
f Vastus externus muscle
g Rectus femoris muscle.
h Vastus internus muscle.

FIG. III.—OBLIQUE LATERAL VIEW OF RIGHT STIFLE.

a Internal vastus. *b* Rectus. *c* External vastus. *d* Patella. *e e* Pins showing position of trochlear ridges.

FIG. IV.—ANTERIOR VIEW OF LEFT STIFLE WITH FEMORO-PATELLAR CAPSULE OPENED.

a Femoral trochlea.

b b Synovial clots.

c Location of patella.

d Abraded external trochlear ridge.

FIG. V.—OBLIQUE LATERAL VIEW OF LEFT STIFLE WITH CAPSULE OPENED.

a Femoral trochlea. *b b* Synovial clot. *c* Patella. *d* Abraded external trochlear ridge. *e* Femur. *f* Tibia.

INHALATION PNEUMONIA.

By W. L. Williams, Professor of Surgery, and P. A. Fish, Professor of Therapeutics at the New York State Veterinary College.

A Paper read before the United States Veterinary Medical Association at Nashville, September 9, 1897.

The inhalation of foreign bodies, whether mechanical, chemical or bacterial tend usually toward bacterial invasion of the bronchial mucosæ, extending thence to the deeper parts, finally involving all tissues of the lungs, inducing suppuration, necrosis and death.

The symptoms vary greatly in detail, though in general present the ordinary signs of bronchitis and pneumonia, along with expectoration of fœtid bronchial secretions, with such variations in chest sounds as would result from the presence in the tubes of the foreign bodies inhaled or of the products of disease.

The most common causes are the inhalation of medicines during their forced administration, of food particles during coma, as in parturient apoplexy of the cow, of pathogenic organisms and their products after arytenectomy for the cure of laryngismus paralyticus in horses or other operations involving the upper air passages, by the inhalation of pus discharged into the fauces or upper air passages from abscesses, diseased teeth or tumors, by animal parasites in the air passages, by the inhalation of irritant gases, or hot smoke, or of liquid chloroform during the production of anæsthesia and by a great variety of more rare accidents ending in the lodgment of irritant foreign bodies within the air passages.

We might include also a highly important class of infections like diphtheria, in which there is a tendency for the extension of the lesions to the lungs, or of tuberculosis, actinomycosis and glanders, where there frequently occurs necrosis and softening of patches of lung tissue, which, discharging into the bronchii, tend to pass upward, only to be in part carried backward into neighboring bronchii, establishing there their typical patho-

logical processes in that manner commonly termed auto-infection.

The handling of these cases has, as a rule, proven ineffectual, and led practitioners to recoil from them with well founded dread.

The plan of treatment usually adopted has consisted of the internal administration of expectorants and sedatives with some of the gum-resins possessing antiseptic properties and which are largely excreted by the lungs, and the inhalation of vapors, either simple or medicated.

Intra-tracheal injections of vermicides have been successfully employed in verminous bronchitis, and the bronchial mucosa has been used as a prompt and reliable absorbent surface for the administration of various drugs in solutions of small volume. The senior writer has attempted the administration of antiseptics in small volumes by intra-tracheal injection in cases of suppurative bronchitis, and has endeavored to aspirate suppurative areas of the lung and inject the cavities with antiseptics, but without noteworthy success.

Beaumont Small (Handbook of Med. Sci. IX, 756) employed a 1 to 500 solution of pyoktanin in the form of intrapulmonary injection of 8 to 16 minims in pulmonary tuberculosis, which was reported well borne, except that when reaching the bronchii it caused violent coughing, but was said to have lessened the hectic condition and diminished the number of bacilli in the sputa.

We have been unable to find record of any attempts to administer per trachea for therapeutic purposes, large volumes of liquids either as mechanical detergents or as topical or general antiseptics, the filling of the lower air passages with liquids being associated in the popular mind with drowning.

Opposed to this fear existed the well-known fact that in partial drowning the water which had well filled the air passages was in many cases partly drained out, largely absorbed, and the patient left little worse for the experience beyond the physical shock.

It had also been shown experimentally that large quantities of water could be slowly introduced into the lungs through the trachea and become absorbed without untoward results, while a like volume introduced rapidly and persistently would produce profound disturbance and eventually death. Notwithstanding that absorption occurs more rapidly in the lungs than elsewhere in the body, excess of fluid effects material changes not only in the respiratory epithelium, but also in the blood in which any change must necessarily affect all other tissues.

In an experiment at Lyon, France, under the direction of Gohier, 30 litres (7½ gals.) of water were injected into the trachea of a horse without causing death. In another case it required 40 litres (10 gals.) to kill the animal by suffocation. Colin (1873, Vol. 2, p. 109) experimenting along the same line introduced into the trachea of a horse by means of a special apparatus, 6 litres of water per hour at a temperature of 30 to 35 degrees C., which was continued for 3½ hours, making a total of 20 litres, after which the animal was immediately destroyed, the bronchii quickly opened, but found empty, all the water having been absorbed.

In another horse he introduced into the trachea 25 litres of water in six hours, and bled him three times at intervals of two hours, obtaining 6 kilogrammes ($13\frac{2}{10}$ lbs.) of blood. The respiratory mucosa absorbed all the water without apparent inconvenience to the animal.

Intra-tracheal medication, though not in general use, has much to recommend it when rapid effects are desired, especially in those pulmonary diseases where antiseptics are indicated.

Among the agents best adapted for this use, is hydrogen peroxide, which is antiseptic, non-toxic, deodorant, styptic, and in dilute solution non-irritant.

With these facts and suggestions before us, two cases were presented at the clinics of the New York State Veterinary College, which served to invite more radical attempts at intra-tracheal medication than had previously to our knowledge been undertaken, the results of which were to us at once so unex-

pected and instructive, that we felt ourselves warranted in communicating them to the profession, though admitting that our experiments were preliminary and quite incomplete.

Case I. was an adult roadster gelding, vigorous and sound so far as known except well marked laryngismus paralyticus, on which account he entered the clinic for the removal of the left arytenoid cartilage. After careful dieting he was cast for the operation on June 3d. General anæsthesia was omitted and cocaine used to produce local insensibility. A tracheotomy tube was inserted some twelve inches downwards from the larynx, after which the arytenoid cartilage was excised in the ordinary manner by the senior author of this paper. The patient fought viciously throughout the operation, and the day being warm he became very hot and bathed in profuse prespiration.

The operation completed, the tampon trachea tube was inserted and the operation field tamponaded with absorbent cotton and iodoform.

When released, the patient required assistance to regain his feet, and was so greatly exhausted that he was placed in slings.

On June 4th the tampon and canula were removed, the operation field carefully sponged with 1-1000 sublimate solution, and the horse was permitted to drink a goodly quantity of milk, which he apparently relished. From this time until June 10th the patient seemed bright, drank liquid food with avidity, temperature was normal, and all appeared well except an abundant and ever-increasing fœtid purulent discharge from the nostrils and tracheal openings.

On June 10th he appeared weaker and had fallen down, but was quickly assisted to his feet, and the fœtor of tracheal discharges still increasing, we injected small quantities of hydrogen peroxide into the trachea, which caused the discharge of some froth.

On the 11th well-defined suppurative broncho-pneumonia was noted, the patient was rapidly failing, and the area of disease was so great that the intra-tracheal injection of small volumes of antiseptics could promise no benefit. At this juncture

Professor Law suggested that as an experiment on a hopeless case we might, in the light of the experiments noted above, attempt the administration of antiseptics by the intra-tracheal injection of large volumes of liquids and permit them to be absorbed from the pulmonary mucosa. We prepared a tepid solution consisting of 5 litres of water, 30 grammes sod. chlor. and 60 c. c. of the commercial solution of hydrogen peroxide.

Placing this in an irrigating reservoir at an elevation of ten feet above the animal, with the liquid gravitating downward through ⅜ inch rubber tubing and escaping through a ¼-inch nozzle, the latter was inserted in the tracheal opening and the liquid allowed to flow into the trachea in a full stream until about one litre had entered, when by an expulsive effort the greater part was thrown out through the tracheal openings, mouth and nostrils, the liquid emerging frothy and carrying with it fœtid discharges. As soon as that which had been thrown into the trachea was well out the process was quickly repeated until within 10 minutes the entire 5 litres of liquid had passed into the trachea, the greater part of it having been thrown out again, carrying with it much putrid material.

This was accomplished without apparent distress to the patient, causing only a moderate amount of coughing with each expulsive effort, and leaving him at the conclusion of the ordeal apparently without additional fatigue and with the fœtor of his breath very effectively diminished, his air passages clean and to all appearances the local conditions materially improved. The patient died on the following day without our having repeated the treatment, and the autopsy showed extensive necrotic broncho-pneumonia.

The only result gathered from the case was the facility with which large volumes of liquids could be rapidly introduced into the trachea without producing inconvenience to the animal worthy of remark, at the same time thoroughly flushing out the air passages and measurably deodorizing and disinfecting them.

Case II. was in all material respects like I operated upon on June 4th this year, in the same manner as No. I. by student H.

The patient struggled less violently than I., and was less fatigued after the operation.

Tampon and tampon canula applied as in I. and removed on following day.

Deglutition very imperfect, almost all fluids taken into the pharnyx being expelled through the nostrils and tracheal openings.

From June 6th to 12th the loss of power of deglutition continued unabated, and there were no notable changes except that gradually increasing fœtid discharges took place from the nostrils and tracheal and laryngeal openings. By the 13th of June the patient had become exceedingly weak, having been practically without food, either solid or liquid, for nine days. At this stage the tracheotomy tube which had been removed on June 6th was replaced as a precautionary measure, and the patient allowed to eat succulent grass and soft bran and linseed mashes, of which he partook sparingly, much of it dropping out through the laryngeal opening. By June 17th the breath had become very fœtid, which on the 18th had become excessively stinking.

An examination of the tracheal wound revealed a necrotic piece of cartilage which was excised. We then introduced into the trachea 5 litres of tepid water, with 30 grammes sod. chlor. and 60 c. c. solution of hydrogen peroxide, which flowing in rapidly was largely expelled, flushing thoroughly the air passages, pharynx and surgical wounds, cleansing and deodorizing the parts.

On the 19th the fœtor seemed so much less that the irrigation was omitted, but on the 20th the fœtor had increased and the lungs were again flushed out like on the 18th without inducing any marked discomfort. The intra-tracheal treatment was now discontinued.

After this the patient seemed to improve slowly if at all, in strength, appetite and power of deglutition, and was greatly harassed by a persistent cough. The tracheotomy tube was removed on June 25th, as the power of deglutition now seemed restored, and by July 14th the tracheal and laryngeal wounds

had closed, but the cough continued, the patient remained emaciated and weak, the appetite indifferent, the breath had again become fœtid, especially evident during his fits of coughing, during which he expectorated through the mouth or expelled through the nose dirty gray very fœtid discharges. As there was evidently still some serious pathological condition present, we re-opened the laryngeal and tracheal wounds for examination, finding each completely healed and all adjacent parts apparently normal.

We had barely completed our physical examination of the parts when in a fit of coughing he expelled through the laryngeal incision an excessively fœtid dirty grayish tenacious mass which it could now be no longer doubted had emanated from low down within the bronchii and indicated local purulent bronchopneumonia.

We then began anew the irrigation of the bronchii, the volume, composition and mode of administration of the fluid remaining the same, and being repeated daily.

On the 15th we began the internal administration of quinine sulphate, ℥ i, nux vomica grs. xx, and arsenic grs. ii, twice daily.

At the first expulsive effort during each irrigation, the patient expelled with the water about 10 c. c. of a dirty gray very fœtid tenacious discharge, and on July 17th, he expelled a piece of fœtid necrotic tissue estimated to weigh 2 grammes.

On July 18th, the volume of water was reduced to 3 litres, the sodium chloride correspondingly, leaving it at 6%., while the volume of hydrogen peroxide was left unchanged.

On July 19th, five days after the beginning of the regular daily irrigations, the fœtor of the expectorated mass had greatly diminished, while its color had changed to almost that of ordinary mucous.

July 20th no fœtor could be detected in expectorate, nor in expired air.

July 26th, the hydrogen peroxide was doubled, which caused more coughing and resulted in increased discharge of bronchial

secretion on the 27th and 28th, though the hydrogen peroxide had been reduced on the 27th to the original amount and was so continued thereafter.

By July 31st the patient had markedly improved in every way, was gaining rapidly in flesh, the cough was less frequent, the bronchial discharge less, and seen practically only at times of irrigation, and the animal would run and play in the paddock.

The use of the tracheotomy tube, through which injections were made, was dispensed with on July 30th and the nozzle of the injecting tube inserted directly in the trachea with an apparent advantage in causing less coughing.

On August 2d the patient had so far recovered that treatment was discontinued and the tracheal wound permitted to close.

August 7th he was hitched to a buggy and tested at a rapid pace up a steep hill, and found apparently much improved in wind.

On August 12th he was driven home, a distance of twenty miles, without showing signs of fatigue. On August 31st the owner reported the patient much improved in flesh, practically free from cough, almost free from respiratory difficulty when driven rapidly, and taking exercise work daily without fatigue or other difficulty.

While our experiments were very limited in extent, and can be regarded only as preliminary and suggestive, some facts have been established which appear to us of interest.

It has been shown that large volumes of water can not only be introduced slowly into and absorbed from the lungs, but that such quantities can be introduced into the trachea and bronchi at a rapid rate, if the trachea is open, and be thrown back through trachea, larynx, pharynx, mouth and nostrils, thoroughly flushing these parts, constituting thereby our most efficient cleansing procedure. We have shown that the air passages tolerate quite well at least one antiseptic, hydrogen peroxide.

Of great interest it appears to us, is the fact that on July 17th, during our irrigation we flushed out a large sized piece of necrotic tissue which must have been lodged low down in the bronchi. In each case we apparently cleared the bronchi, at least the larger ones, of any foreign matter, and we certainly are warranted in believing that the irrigation of the lungs exerted a very favorable influence on the course of the disease.

Our efforts suggest a much wider range of usefulness. In accidental inhalation of drugs during drenching, it seems that irrigation may in safety be depended upon to wash out oils, to dilute and wash out such irritants as alcohol, turpentine, whiskey, chloral, etc., while in case of foreign bodies of considerable size, it offers us a means for their removal, quite worthy of a trial. It seems quite possible that good results might be had by this plan in such affections as pulmonary tuberculosis where large softening areas communicate with, and discharge into bronchi, and in all forms of suppurative broncho-pneumonia, and possibly also in extensive diphtheritic invasion of the air passages.

Perhaps one of its most direct uses will be found in the prevention of inhalation pneumonia after arytenectomy, as it affords us not only a safe plan for thorough irrigation of the field of operation, but the fluid passing down the trachea into the bronchi flush out and destroy any pathogenic organisms which have been inhaled.

We do not say that our plan, formula or rate of administration is the best, other antiseptics may be better and other rate or details of administration may be far superior.

We do not know if it is better to have a tracheal or laryngeal opening or not, though the absence of a counter-opening might, it seems to us, lead to dangerous spasmodic closure of the larynx.

The rate of administration can evidently be varied. We did not know at the beginning of our experiment the rate of administration by the experimenters quoted, and departed widely from their plan by introducing the liquid at a very rapid rate,

quite too rapid to permit of total absorption, and in that way learned that we could, without discomfort or injury, have it quickly expelled, and thus we learned by comparison with Colin's and Gohier's experiments that we may at our option, by varying the rate of administration, either have the liquid absorbed or rejected, or partly absorbed and in part expelled. At some times we apparently had 50 per cent. or over absorbed, though always given rather rapidly, while in other cases nearly all appeared to be rejected.

We have been led to hope that in spite of the meagre experience upon which we have based our communication, the facts and suggestions will suffice to lead others to study the plan of treatment herein outlined, with a view to developing a successful method of therapeutics in this heretofore baffling group of affections.

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THE AIR SAC MITE OF THE FOWL.

Cytodites Nudus. Ger. *Cytoleichus Sarcoptoides.* Meg.

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Although the air sac mite has been studied by numerous European investigators at various dates since Gerlach's first description in 1858, we have found no record of the occurrence of the parasite or a disease referable to it in any English-speaking country, and, indeed, find but a brief mention of either parasite or disease, consisting of a mere outline, by Neumann (Non-microbic Parasites of Domestic Animals. Translated by G. Fleming.)

During my official connection with the Montana Agricultural Experiment Station at Bozeman, Mont., from 1893 to 1896, the disease was extremely prevalent, and favorable opportunity was offered for clinical observations, which have been augmented more recently by importing and cultivating the disease at this college.

The malady first attracted my attention by invading some pure bred fowls imported from the Atlantic States to Montana by the Experiment Station for breeding purposes. These were apparently healthy at the time of their arrival, and remained so for three or four weeks. Their permanent quarters not being ready they were placed temporarily in yards where occasional losses of poultry had previously occurred without attracting special attention. By the time the permanent quarters were ready a serious and fatal diarrhœa had broken out among the turkeys, followed in a few days by a similar outbreak among the chickens, and, continuing to spread slowly during the summer, caused a loss of over 30 per cent. of the adult birds and about 50 per cent. of the chicks.

The chief symptoms of the disease were profuse diarrhœa, extreme debility, and either cyanosis or paleness of the comb. The post-mortem appearances consisted chiefly of a diffuse enteritis, the posterior bowel being chiefly inflamed, and co-existent with this there appeared on the transparent membranous walls of the air sacs about the intestines, numerous minute opaque appearing objects, which, upon examination, proved to be air sac mites.

Inquiry being instituted, it was learned that poultry-raising in Montana was generally unprofitable, owing to frequent heavy losses, largely from a malady simulating in symptoms that which was engaging my attention, so that with numerous natural advantages as to food and climate, the major portion of poultry and eggs consumed in the State was imported from a long distance at high rates, and deteriorated in quality because of the long shipment.

It was further ascertained that the monetary loss in the Gallatin Valley, the most important agricultural area in the State, was quite as great from poultry diseases as from those of any other kind of domestic animals, and as far as could be learned, it seemed that the most serious and persistent malady of poultry was that due to the air sac mite.

The literature obtainable in other languages indicates that various investigators ascribe to this parasite a considerable economic importance, but none of them attribute to its presence the gravity which it attains in Montana and perhaps some neighboring Rocky Mountain States.

The disease was first studied by Gerlach,* who relates that in 1858 his attention was called to a fatal affection in a flock of a few more than twenty Cochin China fowls, among which in a short time twenty died, which upon post-mortem examination revealed extensive muco-enteritis and inflammation of the oviducts, and in the bronchial tubes and their dependencies, the air sacs, he found numerous small mites, either solitary or in clumps. Although Gerlach could not directly connect the enteritis with the presence of the parasites, he could find no other

* Magazin für die gesammte Thierheikunde, 1859, p. 233.

cause for it and concluded that they were in some manner responsible for the fatal lesions.

The parasite was described by Zundel * in 1864, one of whose clients had for a time been annoyed by a serious mortality among his fowls, losing two or three daily, and finally asked Z. to determine the cause of death.

The affected birds showed no very marked symptoms of any common ailment, continued to eat, but became very weak, voiceless, their wings drooping and their combs and wattles discolored and pale as a result of anæmia. Post-mortem examination showed moderate emaciation. The intestines were of a rose color, with great engorgement of the mesenteric vessels, while the intestinal mucous membrane was dark red, the intestine much thickened and contained a large quantity of thick, slimy mucous. Large quantities of the parasites were found free upon the walls of the air sacs within the abdomen, and, no other cause presenting itself to explain the fatal lesions, they were ascribed to the mites.

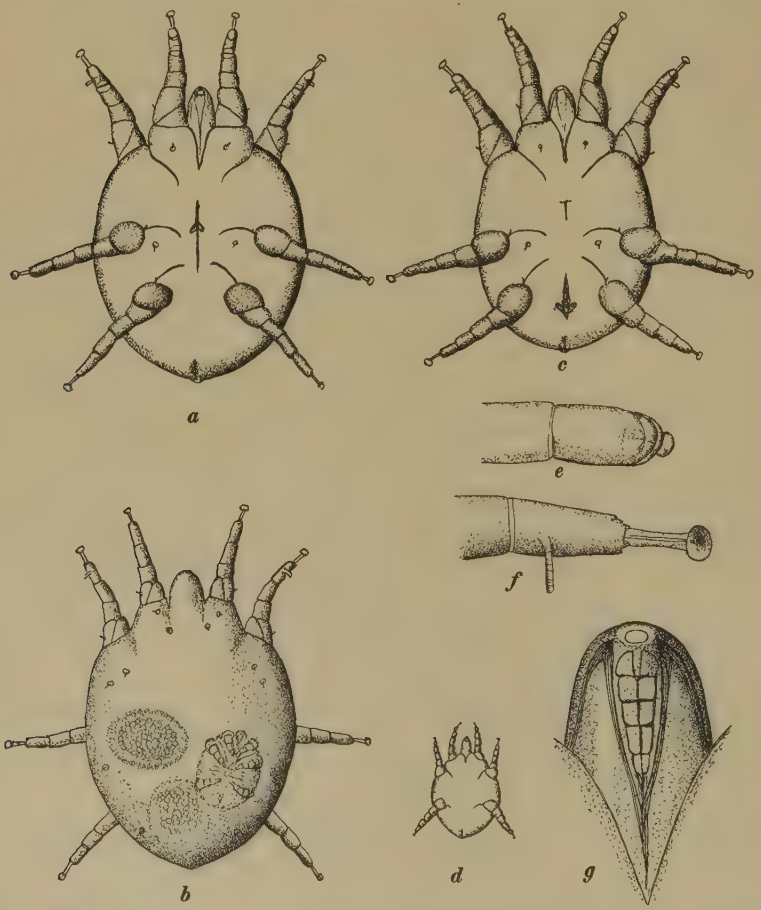
Megnin† in 1879 gave an excellent technical description of the parasite, failing to attach that importance to its presence in the bodies of fowls attributed to it by Gerlach and Zundel.

THE CYTODITES NUDUS OR CYTOLEICHUS SARCOPTOIDES is more closely allied in its anatomical characters to the sarcoptes than to the other classes of acarina. It has for its chief characters a large orbicular body, convex above, the convexity being more abrupt from side to side than anteroposteriorly, giving it a tortoise-like shape ; flat below, extended in front by a movable rostrum, which can be largely retracted. It has a translucent body, varying in color and transparency by exposure to light and media in which it is studied. Taken fresh from its normal habitat, and examined under low magnification, the body seems almost wholly colorless, while the body contents appear as masses of pale lemon-colored oil-like drop-

* Zundel, La Phthriasis Interne. *Jour. de Med. Veterinaire*, Dec., 1864.

† Megnin, Les Acariens parasites du tissu cellulaire et des reservoires ariens chez l'oiseau. *Jour. de L'Anatomie et de La Physiologie*, 1879, p. 123.

lets. The skeleton is chitinous, smooth and glabrous without visible markings on the dorsal surface except six pairs of small caruncles (Fig. *b*), each bearing on its truncated end a small fine hair, the first pair on a line with the axis of the first pair of



legs, equidistant from the margin anteriorly and from either side of the slight obtuse prolongation of the body from which the first pair of legs proceeds. The second pair is more posterior, twice the distance of the first pair from the anterior margin and in a line with the notch between the rostrum and the

protuberance for the first pair of legs. The third pair of bristles is located at about the same distance from the body margin as the second and almost in a line with the axis of the second pair of legs, while the fourth pair is located backwards and outwards from the latter, almost midway between the second and third pairs of legs; the fifth pair almost marginal at a point equidistant between the third and fourth legs, while the sixth pair occurs near the margin, one-third the distance from the fourth leg toward the anus. On the ventral surface (Figs. *a* and *c*) two pairs of hairs are found, one between the epimera of the first two pairs, the other between those of the fourth and fifth pairs of legs.

The rostrum (Fig. *g*) which can be almost wholly retracted within the camerostoma is conical with a rounded extremity pierced in its centre by a circular opening. The mandibles and maxillæ are not distinct, but fused together to form a tube ending anteriorly in the circular opening. Dorsally (Fig. *b*) the rostrum offers no markings, while ventrally (Figs. *a*, *c*, *g*) there is seen a dark line beginning centrally at the base by a sharp point gradually widening for one-third the rostral length, where it divides into two lines diverging at an acute angle to end on either side of the circular opening, at which point it is joined at an acute angle by a second similar line extending along the margin backward to the base. Within the triangular space between the circular opening of the oral tube, and the two first mentioned lines is a double tessellated organ of five articles apparently representing the maxillary palpi and forming the lower lip. No mouth organs capable of biting or penetrating tissues are discernible, the parasite feeding by sucking up the liquid secretions of the membranes which it infests.

The legs are of medium length; large, conical and strong, with five distinct articles terminated by a pedunculated retractile ambulacrum (Figs. *e* and *b*) which is cylindrical, ending in a campanulated sucker; the anterior two pairs almost marginal; the first pair directed almost straight forwards, close alongside the rostrum, bears on the external margin of the trochanter

a short bristle directed outward and forward, while at the tarsus at the base of the ambulacral sucker, there at times appears to be another hair or projection which is probably rather a folding of the chitinous covering of the foot. The second pair of legs (Fig. *b*) shows in addition to these hairs, an elongated retractile spur, pointing upwards and backwards from the tarsus, at right angles with it, about as long, though not as thick, as the ambulacrum. The epimera of the first pair unite on the median line to form a triangular sternite; the apex directed backwards, the base occupied by the rostrum. The epimera of the second pair are free and slightly arched or sinuous. The two posterior pairs of legs are large, glabrous and almost as strong as the two anterior pairs, their epimera free and arched, the convexity being forwards, and each showing near its base a short spur-like projection, extending forwards; the coxæ very large, globular. Anus hypo-marginal.

The ovigerous female (Figs. *a* and *b*) varies in size from .45 to .66 m.m. long, and .38 to .55 m.m. wide. The vulva is between the epimera of the two last pairs of legs, extending forward almost to the epimera of the second pair, and consists of a longitudinal cleft, wider in front than behind, and furnished on either side at its anterior third with a short obtuse prolongation inclined backwards and outward like the barbs of a harpoon.

Within the transparent body there is always observable two to twelve ova in various stages of development, one to six or seven of which contain six-legged larvæ (Figs. *b* and *d*), the legs readily distinguishable folded on the ventral surface of the body. By slight pressure on the cover glass the larvæ can be pressed out of the female and show after their extrusion energetic movements.

The parasite deposits no eggs, but gives birth to living young, is ovo-viviparous, and the extreme variations in size, as noted above, are due to the number of ova contained within the body.

The male is .45 to .50 m.m. long, and .38 m.m. wide, presenting on the middle of the ventral surface a well-marked

sternite with a transverse guard at its anterior end. Penis between the epimera of last hind legs and anus, extending over half this distance, conical in form, and bearing near its base an obtuse semicircular sternite. The young non-gravid female is distinguished from the male by the absence of genitals, copulation being effected through the anus, as in most acaria. The nympha and octopod larvæ differ in appearance from the non-gravid female only in size, no genital system, either male or female, being yet developed.

According to Megnin, the six-footed larva is rarely seen, as it quickly moults. We have failed to find it except in the body of the gravid female.

The Cytoleichus Sarcoptoides has its chief habitat in the air sacs of the gallinaceæ, especially in the common fowl. They have not been found outside the body nor in other parts than the air sacs and their communications: the lungs, bronchi and hollow bones. By reason of their comparatively large size they are readily discovered by the unaided eye, being observed upon the thin pellucid walls of the air sacs as small white particles, like grains of fine meal. At times, they are found somewhat widely scattered; generally they tend to collect in groups. Soon after the death of the fowl and opening of the body, they tend to congregate in clumps within the deeper and darker recesses of the air sacs behind the kidneys, etc. Although they can in some cases be found in the hollow bones which communicate with the air sacs, and in the bronchial tubes, they are not as a rule so readily found in these parts, and but rarely exist there in great numbers. They are readily picked up from the air sac walls on the point of a knife or needle, or easily washed off with a stream of water. They exhibit no power of attaching themselves to the walls of the sacs beyond that required to maintain their body weight. Neither do they possess the power of firmly attaching themselves to each other. Though they congregate in groups in the cadaver of the dead bird or when floating on a liquid, yet they are readily drawn apart, and unlike many acaria they do not appear to become

firmly attached to each other during copulation, so that we have failed to observe the copulatory process.

These observations, in connection with the anatomical characters of the parasite, fully support Megnin in his opinion that prior observers had erred in attributing to the mites serious mechanical irritations, though failing, in our judgment, to warrant him in concluding that they do not cause serious and fatal disease. It is evident that in their usual habitat and with their anatomical structure their sustenance must be derived from the liquids secreted by the membrane upon which they congregate and sucked up by the aid of their tubular mouth parts.

The parasite seems peculiarly erratic in its appearance under the microscope, so that the details given by no two authors consulted fully agree with each other nor with those here given. Gerlach figures and describes an acarus wholly nude, both in body and legs, while Railliet (Neumann's Parasites of Domestic Animals, pp. 243–4) figures a nude body, but with the two anterior pairs of legs bearing small, almost transverse, hair-like elevations, in length almost as great as the thickness of the leg. Megnin adds several hair-like projections emanating from little elevations on both the dorsal and ventral sides of the body, figures the same hair-like projections on the two anterior pairs of legs noted by Railliet, and adds to the second pair of legs, at the middle of the last joint, a large spur pointing backwards, two-thirds as long as the ambulacrum and almost as thick, while Zurn, in his "Diseases of Poultry," p. 62, figures the bristles on the body, omits those on the extremity except that in the place of the prominent spur figured by Megnin he figures a tapering bristle almost double the length of that spur. It is not at present possible to fully explain these discrepancies in figures and descriptions. They do agree sufficiently in all essential particulars to make it evident that each had to do with the same parasite.

Although we assume that in passing from one fowl to another the parasite must for a time live outside the body, its discovery in a free state has not been recorded. Left in the body of a dead fowl in a room at a temperature of 70° F., it

lives for four or five days, if protected by the tissues from desiccation. Placed in a normal salt solution, the parasites quickly cluster together in an intricate mass and either remain swimming on top of the solution, or descend to the bottom of the vessel, in either position keeping up almost constant movements of the feet and rostra, without appreciable change in the location of the clump. If one be separated from the cluster it usually rejoins it promptly. In this condition they live and remain apparently quite vigorous in a room at about 70° F. for a period of five to eight days. They appear to be quite indifferent as to whether submerged in water or floating on its surface. Removed from moisture, they quickly dessicate and die.

There is great variation of opinion among the different observers as to their power to cause serious disease.

Gerlach and Zundel were alike positive that they caused serious losses among the poultry of their clients, while Megnin and others are as certain that the former were in error and that it is only possible for them to do great harm when collecting in great masses and blocking up the air passages; a very rare occurrence.

Gerlach thought the enteritis he observed was most likely due to migrations of some immature or larval form boring its way through the tissues, but Megnin very properly states that this cannot be, as the mouth tissues are tubular, that the parasite can only suck up fluids about it and is utterly incompetent to burrow in or through the tissues. When it is remembered also that the entire development of the parasite from ovum to six legged young, can be watched in the body of the female, in which state, if not in its eight-legged form, it is born with mouth parts like the adult, it is evident that we see the entire life cycle of the mite and that at no date in its history is it able to burrow or bite; and since the body and extremities are practically free from any hairs or projections capable of inducing any severe wounds or abrasions, it must be admitted, as Megnin states, that no serious results should follow their presence in so far as mechanical irritation is concerned.

Holzendorff* alone of all authors consulted states that he has found these parasites buried in the liver, kidneys or other tissues, but while he denominates the parasite Cytoleichus Sarcoptoides he neither figures nor describes it and it seems very improbable that he really had to do with the mite in question.

Although I am unable to define the manner, I am nevertheless thoroughly convinced with Gerlach and Zundel that they do produce disease and death. Like Gerlach and Zundel I have made numerous autopsies on fowls in which there could be nothing discovered to account for disease or death except these parasites.

Making a great number of autopsies on any and all affected fowls available for a period of one and one-half years some have been found which were quite free from this parasite but showed lesions which would clearly account for their ill health or death, others revealed more or less numerous mites along with a variety of lesions which could not with our present knowledge be attributed to the presence of the parasites, while in most of the birds examined no cause other than the immense numbers of cytodites could be assigned.

The symptoms of disease observed in those cases where no other evident cause than the presence of these parasites could be detected before or after death, while not wholly uniform, were quite as much so as could be expected when we consider the area over which the mites may be distributed and the variable symptoms possible for their location. Most constant and prominent of all symptoms was the profuse diarrhœa, the fæces being thin, yellowish-white, apparently granular, and very glutinous, adhering to the feathers about the anal opening in large masses. At the same time the bird becomes dull, drooping and feeble, although retaining a fair appetite and in some cases remaining fat until far advanced in the disease. The plumage gradually loses its lustre, becomes dirty, ragged looking, and much dishevelled. If the bird is left to itself it may move about fairly well, but if forced to run it quickly becomes exhausted,

* Archives für wissenschaftliche und praktische Thierheilkunde. B. 11. p. 304.

its breathing becomes quick and labored, the mouth being held wide open. The comb and wattles show marked but variable changes, becoming either very dark blue, cyanotic, chiefly in fat fowls, as a mark of asphyxia, or of a pale whitish color in the poorer ones, as a result of extreme anæmia. In all cases these parts are much reduced in size, as they are essentially sexual attributes, and diminish in size with the decadence of sexual powers, which supervenes early in the affection.

In adult birds it usually runs a somewhat chronic course, extending over several days, not infrequently two or three weeks, and in some cases a like number of months. In some cases there may be remissions of the disease, continuing severely for some days or weeks, then abating for a time, to almost surely appear later. It is fatal in nearly every case. Birds two months to one year old are rarely attacked, but well-marked cases have been observed. Sex has an apparently well-marked influence, so that while the disease existed in the Experimental Station yards it was almost impossible to keep breeding cocks, and so far as I can learn these suffer most.

Breed has little influence, the heavy Asiatic varieties apparently suffering somewhat more severely. The disease occurs chiefly during rainy months, either in fall or spring.

The post-mortem appearances vary somewhat, but are characterized chiefly by enteritis and peritonitis.

The enteritis is of a disseminated character, extending throughout the greater extent of the intestines, but affecting most intensely the posterior portions of the bowels, the mucous membrane suffering chiefly, extending to the other intestinal coats if the enteritis is very severe. The mucous membrane is swollen, reddened and gives a general injected appearance to the entire affected bowel. The intestinal contents in the inflamed portions are thin, yellow or yellowish white, and stringy. The mucous membrane is covered over with a considerable amount of slimy mucous.

The peritonitis, when present, is diffuse, the peritoneum of a reddish or dirty gray color, the peritoneal cavity more or less

filled with a dirty brownish serosity, usually turbid. This peritonitis does not appear to be a sequel to the enteritis by extension of the inflammatory process through the intestinal walls, but rather the direct effect of the same factor which induces the enteritis. The liver is usually somewhat enlarged and pale in color. The heart, kidneys, gizzard and anterior portions of digestive canal are normal. The lungs are in some cases inflamed and hepatized ; the bronchi, too, are not seldom the seat of some irritation, causing a mucous discharge from the nostrils.

To these we add the actual presence of the parasites in great numbers in the air sacs and their dependencies. They are so large as to be readily recognized by the unaided eye if a proper search be made. They are found chiefly in the air sacs within the abdomen, and are readily seen as small, partly transparent, glistening, white or yellowish white globular bodies like fine grains of meal, adhering either singly or in groups almost countless, to the fine, thin, transparent bladder-like walls of the air reservoirs ; more readily still are they seen upon the smooth, dark surface of the liver or kidneys, the dark background making the white parasite conspicuous. The parasite is readily lifted from its position on the point of a knife or pin, and can be examined on a piece of glass or a smooth black surface, where, if watched, its movements may be observed without the aid of a microscope.

CASES.

No. 1. A two-year-old partridge Cochin hen, property of the Experiment Station, became unwell early in March, 1895, was noticed to be somewhat dull, laid no eggs, her comb became a dark bluish purple, as though the bird was partly asphyxiated, the anal feathers were matted together with yellowish, glutinous, stringy, diarrhœic fæces. If made to move, she at once began to breathe rapidly and heavily, the mouth being held wide open to facilitate respiration.

The hen was destroyed April 5th by bleeding and an autopsy made at once. The body was found *very* fat. All inter-

nal organs were found healthy so far as could be determined by a careful seriatim inspection except the lower portion of the bowel, which was inflamed and contained a thin, yellowish, flaky fluid. The air sacs and their dependencies were thickly infested with cytodites.

No. 2. A partridge Cochin hen, same age and lot as No. 1, with identical history as to date and symptoms. Weight at time of killing 9 pounds. Killed by bleeding. All internal organs found healthy except muco-enteritis of the lower intestine. Cytodites were in countless numbers in the various air sacs. Like No. 1, No. 2 was excessively fat when destroyed, but did not lay before being killed nor did the condition of the ovary indicate early laying.

Case No. 5. Brown Leghorn cock, aged two years, imported from Massachusetts, March, 1894. During the breeding season of 1894 he was mated with six hens, during 1895 with ten. He was well cared for, had ample food, both in quantity and variety, with abundant range, and free access to clean running spring water, and had been apparently in perfect health at all times until July, 1895, when it was noted that his comb had an abnormal hue, being somewhat purplish or bluish, his plumage losing at the same time to a degree its usual lustre, yet he appeared lively and associated with the hens as usual. The hens were laying well, but the eggs, which showed an average fertility during the spring, began to decline in fertility and early in July became almost sterile, indicating a loss of sexual powers. From this time the symptoms of disease increased steadily, the comb and wattles gradually becoming a pale blue, then a pale bluish white, and gradually decreasing in size to one-tenth their normal proportions. The plumage gradually lost its lustre, became ragged, dishevelled to an extreme degree. General weakness, with emaciation, became apparent and the bird ceased to accompany his mates, but remained apart from them, listless, inattentive to surroundings.

During the entire course of the disease there were observed no signs of diarrhœa. On October 8, 1895, the disease had pro-

gressed so far that the bird was scarcely able to walk, the plumage was devoid of lustre, the bird wasted to a mere skeleton, the comb and wattles pale, bloodless, shrunken, respiration quickened, difficult and accompanied by a rattling noise.

The bird was killed by bleeding. The autopsy revealed an exceedingly emaciated, anæmic body; the body cavity contained a quantity of a thickish dirty gray pap-like fluid. The mesentery showed numerous dark, almost black spots one-eighth to one-fourth inches diameter. Everywhere in the air sacs were found many cytodites; the surface of the liver, kidneys and pelvis were thickly dotted over with the parasites. The right lung was inflamed throughout and the greater portion of its tissue firmly hepatized. The bronchi were highly inflamed and filled with a tough white mucous in which living cytodites swarmed, penetrating into the smallest bronchioles traceable with the naked eye. The parasites were also found in the scapulo-humeral extension of the air sac. Testicles were greatly atrophied, being as small as an ordinary peanut.

Case No. 6. Cytodites Nudus, associated with the lesions apparently not due to their presence. Subject property of W. E., a small grade Plymouth Rock hen, one or two years old, had been ailing for some weeks, was emaciated, dull, weak, and on the morning of October 22d was found unconscious and apparently dying. One eye contained a chaff surrounded by a diphtheric membrane. After bleeding, an autopsy revealed great numbers of cytodites in the air sacs. The liver enormously enlarged, weighing 93 grammes, mottled chocolate and dirty yellow in color, and contracting numerous adhesions to the contiguous organs. A small blood clot was present and attached to the surface of the supero-internal face of the left lobe of liver and a similar clot near the entrance of the vena porta, indicating recent hepatic hæmorrhages. Spleen enlarged, oblong, weighing 60 grammes, red and yellow mottled.

From this hen were taken living parasites, which were used in experimental transmission in cases 7 and 8.

Case No. 7. Attempted transplantation of cytodites from in-

fested to supposedly healthy chick, by means of introduction of the living parasites into the air sacs.

Subject, an apparently healthy incubator chick which had not been in contact with other than incubator chicks and on premises supposed to be free from cytodites.

On Oct. 23, 1895, twelve living parasites from Case 6 were introduced into the air sacs of the experiment bird by means of intercostal incision as for caponizing. The subject was then kept apart from other birds except No. 8, and in quarters supposedly free from parasites. No symptoms of disease developed and after an interval of forty-seven days (December 9th) the chick was killed by bleeding and the autopsy revealed a few cytodites in varying stages of development, including young mites and pregnant females. No trace of pathological lesions was discovered.

Case No. 8. Experimental transmission of cytodites to healthy chick by laryngeal injection. Incubator chick with history of No. 7. About twelve living mites from No. 6, suspended in water, were injected through larynx into trachea, and chick cared for as No. 7, without the occurrence of signs of ill health other than those attributed to close confinement.

Autopsy November 6, 1896. No cytodites could be found, and no pathological lesions distinguishable.

Case No. 9. A one-year-old partridge Cochin hen, property of Experimental Station. Noted unwell about December 15, 1895, being very weak, dull, rapid emaciation, quickened and difficult breathing, and feathers much soiled, well marked diarrhœa present, the fæces thin, pale yellowish, stringy. Killed by bleeding, December 26, 1895. Autopsy: Diffuse enteritis, right anterior diaphragmatic air sac contained about 500 cytodites, right posterior diaphragmatic about 200, right abdominal sac 4 oz. of a pale yellowish serosity, slightly turbid. The air sacs on left side were not examined for some hours, when but a few parasites were found in them. No further pathological lesions were observed.

Case No. 10. A brown Leghorn hen, aged three and one-

half years, property of Experiment Station, procured in Massachusetts in 1894, and was apparently well until about December 15, 1895, when she appeared dull, inattentive to surroundings, comb bluish in color, the anal plumage clean, but there was a well-marked diarrhœa present, the fæces being thin, stringy and pale yellow, emaciation marked. Killed January 3, 1896.

The abdominal and diaphragmatic air sacs were found to be filled with cytodites. Left abdominal sac contained a patch of calcareous deposit, white and opaque, about three-fourths inch in area. No further pathological lesions found.

The geographical distribution of the disease is not well known. It has been recognized in various parts of Europe, but so far as we know has not heretofore been recorded in America. It is, or was, highly prevalent in the Gallatin and Madison valleys in Montana, where it constituted a serious scourge to poultry, being more or less prevalent in nearly all poultry yards, and when not inducing evident illness or death resulted in a loss of vigor, the hens ceasing to lay eggs, the cocks becoming sterile and external and internal genitals atrophied.

I also observed the disease in a serious form in the Snake River Valley near Idaho Falls, Idaho, and am led to believe that it is widely disseminated in the Rocky Mountain States.

In those localities where the malady was observed, the altitude ranges from 4000 to 6000 feet above sea level, with a very low degree of humidity. No reason appeared to indicate that the great altitude had any influence in the existence of the disease, and the experimental transmission of the parasites to healthy fowls at this college and the rapid increase of the mites thereby, indicates that if the parasite does not prevail in other parts of the country it is more probably due to a failure of introduction than to climatic conditions.

The natural mode of transmission is unknown, but it can, so far as we can see, only occur by the entrance of the mite through the nostrils after they have first escaped or been expelled from the affected bird by sneezing or coughing. There being generally a discharge of mucous from the nostrils of af-

fected birds, this would facilitate the escape or expulsion of the parasites. Experimentally the parasites are readily transplanted and multiply rapidly. For this purpose we make an incision between the last two ribs as if for caponizing and introduce the parasites in salt solution by means of a dropper.

The constantly increasing importance of our poultry industry suggests the need of a more extended study of this parasite. It seems possible that at any time the parasite may attain a wide and serious distribution in various parts of the United States, and that poultry breeders should consequently be on their guard.

No treatment of a reliable kind has yet been found, and in fact in the present state of our knowledge any attempt at individual treatment is dangerous except in properly controlled experiments. Like other maladies due to the invasion of numerous animal parasites, an apparently sound bird may conceal innumerable mites and act thereby as a centre of infection in new flocks into which it may come.

The only profitable measures at present consist in the extermination of affected flocks and the careful disinfection of houses and yards. So far as we are able to judge, the killing of all birds in the flock, thorough cleansing of habitations and leaving them unoccupied for perhaps ninety days, affords our safest and most economical means for eradication. The refilling of poultry yards offers a renewal of danger which may be effectively met by the use of the incubator. This appliance, whatever may be said of its demerits and eccentricities, constitutes the poultry raisers safe, convenient and impassable barrier against this, as well as numerous other dangerous parasites. This method does not involve a complete change in stock and the throwing away of valuable results already attained in breeding. The eggs for artificial incubation may be safely taken from the infected flock, hatched and kept widely apart from the old birds, until when enough have been obtained the parent stock is destroyed, their habitations disinfected and the fresh uncontaminated young stock of the same lineage is ready to take their places.

EXPLANATION OF FIGURES.

a. Ovigerous female, ventral surface.

b. Ovigerous female, showing ova, one of which shows a well-developed larva.

c. Male, ventral surface.

d. Six-legged larva, extruded by pressure from body of female.

e. Foot with ambulacrum withdrawn.

f. Foot with ambulacrum extended and spur delineated.

g. Rostrum seen from ventral surface.

CAUDAL MYECTOMY VS. CLITORIDECTOMY.

By W. L. Williams.

From the American Veterinary Review, May, 1898. Pp. 90-94.

Various accounts appear in current veterinary literature, from time, to time, of the successful treatment of vicious mares by the removal of the clitoris. It is well known that many, or in fact practically all, of these vicious mares, when kicking or balking, tend to concomitantly switch the tail violently, urinate repeatedly, open and close the vulva rapidly, projecting and withdrawing the clitoris, and in general showing signs which suggest undue sexual excitement.

Apparently regarding this female penis as the seat of important sexual functions, operators have removed it in lieu of castration, though it is known that such animals continue to menstruate and breed as if nothing had occurred, and yet it is claimed that its removal subdues or ameliorates the vice.

Being skeptical upon the question, two cases have entered the college clinic which may suggest a new view of the *modus operandi* of the removal of the clitoris, because in these two cases the viciousness was removed without recourse to genital surgery.

Case I.—A small, rugged, common-bred, aged mare, which had acquired the vice of gripping the reins with the tail, followed by kicking, urinating, etc., and running away, becoming wholly unmanageable, except by tying the tail securely to harness or thill.

The base of each depressor muscle was separately dissected out and cut away for a distance of five inches. The tail was dressed daily until healed, when it was found that the patient had lost her viciousness along with the gripping of the reins.

Case II.—A well-bred trotting mare, used for butcher's delivery, had contracted vicious habits, like the previous case, and had finally become unmanageable after one year's annoyance and danger to the driver.

This animal would constantly try to kick whenever she could catch the rein or when the breeching would press against her in going down hill, the kicking being accompanied by switching the tail and urination.

Placed upon the operating table she was treated the same as the previous animal by student L., and being released was immediately hitched to the wagon and has been kept daily at work without any suggestion of vice.

We have observed equally prompt subsidence of vice in geldings after this operation.

The technique of our operation is extremely simple : the animal being secured in the lateral recumbent position and the necessary antiseptic precautions taken, an elastic bandage is applied firmly from the apex upward to the base of the tail in order to render it bloodless, a tourniquet of pure gum tubing affixed closely to the base of the tail, the compression bandage removed and the operation field rendered aseptic.

The tail being sharply flexed dorsally by an assistant, a linear incision is made over each depressor coccygeus muscle midway between the ischio-coccygeus and inferior *median line* beginning close against the tourniquet and extending for about five inches towards the apex of the tail, severing the skin and caudal aponeurosis, exposing the muscle. The latter is readily separated from its enveloping aponeurosis either with the blade or handle of the scalpel, the envelope being lifted from the muscle with a tenaculum or retractor. A small probe-pointed bistoury is next inserted at the base of the incision on either side of the muscle and the latter completely severed. The dissection is now completed by cutting away the vertebral attachments of the muscle down to the distal end of the initial incision, where it is excised in the same manner as at the base.

The prolongation of the ischio-coccygeus is left intact. The muscles removed, the cavities remaining are tamponaded with cotton or gauze of the form and size of the muscle removed, sutures being omitted. The tampon may be asceptic, or, as we use it, antiseptic, being saturated with 1 to 1000 sublimate solution, a pad of cotton saturated in the same solution spread over the wounds and the tail firmly bandaged, the tornuiquet being removed after the bandaging has been completed as well up to it as possible.

The removal of the tourniquet is the signal for rather profuse hæmorrhage, which quickly subsides. The hæmorrhage appearing so quickly serves to eliminate any irritation from the sublimate within the wound. The bandage is removed after 24 hours and fresh dressing applied and in 48 hours the bandage and tampon may be omitted and the wounds treated once or twice daily with antiseptics. By omitting the use of the crupper the animal can readily continue its work without interruption. Care being taken to make the two sections of equal length, the symmetry of the tail is not changed except it is carried somewhat higher. The preserved ischio-coccygeus serves to prevent any undue elevation of the tail.

As we know of no essential bond of sympathy between the tail and

genitals we can scarcely assume that the myotomy has effected a cure through the medium of the reproductive system.

We are led to think it possible, if not probable, that the education given an animal, by securing it fixedly and performing a painful operation in a region about which it has been previously viciously irritable and is now powerless to evade or resent the pain, plays an important part in the eradication of the vice. If this be true, we should in these operations discard general or local anæsthesia entirely and secure the animal in the most immovable and helpless manner, yet safeguarded against physical injury, which is in our judgment best attained by use of the operating table

Having attempted but the one operation we cannot of course essay to compare the two, though we believe the caudal myotomy has a wider application, being available in geldings. At the same time it wholly removes the power of gripping the reins and renders the tail far more readily handled in every way. Being bloodless, the operation is very easy and can be carried out perfectly by any one acquainted with the details and in location can be more readily kept asceptic than can the operation wound after the removal of the clitoris, though either is not important from the standpoint of infection. It is not intended to suggest that caudal myotomy can properly replace spaying in cases where the latter is indicated.

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INTERESTING CASES

FROM THE SURGICAL AND OBSTETRIC CLINIC, NEW YORK STATE VETERINARY COLLEGE.

BY W. L. WILLIAMS, PROF. OF SURGERY, ETC.

TREATMENT OF FRACTURES IN BIRDS BY RUBBER ADHESIVE PLASTER.

(962) Patient, a white Leghorn hen, æt. 1 year, had in some unknown manner received a complete simple fracture of the metatarsus at the commencement of the lower third. Displacement and mobility were well marked and prohibited the bearing of any weight upon the affected member.

The materials generally applied for the fixation of fractures being too bulky and heavy for so small a patient, recourse was had to the commercial rubber adhesive plaster. A strip of plaster ½ inch wide was gently warmed and applied directly to the foot for a sufficient distance on either side of the fracture, in the form of a spiral bandage, each turn overlapping the preceding.

The plaster secured complete and permanent fixation, was easily and quickly applied, highly presentable in appearance, and gave the greatest possible comfort and ease of movement to the patient. The hen began using the leg naturally after a few hours, and although permitted the freedom of the poultry yard regardless of moisture, the bandage remained securely *in situ* until after the fracture had reunited.

AMPUTATION OF THE POSTERIOR LEG OF A SOW.

(583) Patient, a sow of common breed, had four weeks previously given birth to eight pigs, which she was still suckling. A few hours before being presented at the clinic she had been attacked by a bulldog and the right tarsus severely mangled, the bones of the tarsus being separated from each other and

from the tibia, fibula and metatarsals, the foot being held to the leg chiefly by the posterior tendons and ligaments, the wounds being thoroughly befouled with dirt.

Other treatment than amputation was evidently useless, and accordingly the patient was chloroformed, the limb disinfected, and owing to serious mangling in the inferior tibial region amputation was made by student K. just beneath the head of the tibia. Two lateral flaps were prepared, the chief arteries ligated, the tibia and fibula were sawed through, the flaps sutured carefully, the patient was reloaded into a wagon and returned at once to the owner's premises and placed with her pigs.

On the following day the patient appeared dull, but the wound looked clean, was free from swelling and no injury had occurred to cause hæmorrhage.

On the fourth day the owner reported slight swelling of the stump and the tearing out of one or two sutures, but the patient was brighter, feeding and caring for her pigs, and was moving about some.

On the eighth day the patient was running about on three legs without apparent great inconvenience, and in 15 days the wound was practically healed, the sow in good health and flesh and caring for her brood of pigs apparently none the worse for the injury and loss of a leg.

CASTRATION OF CRYPTORCHIAL BOARS.

(420) Patient, a boar pig, æt. 4 weeks, both testes retained within the peritoneal cavity. Securing the pig on the right side with anterior part of body depressed, an opening was made by student F. in the left flank as if for spaying, the index finger introduced and the left testis grasped, withdrawn from the abdomen and excised, the finger again introduced, passing between the abdomnial floor and intestinal mass until the right testis was encountered and removed in the same manner as the left.

(421) A boar pig of same age as 420, monorchid, the normal testis having been removed by the owner. The abdominal testis was removed by student M. in same manner as 420.

(432) A four weeks boar pig with right testis retained in abdomen, operated upon by student H. in same manner as preceding.

(171) A Chester white boar, æt. about 8 months and weighing about 200 pounds, both testes entirely retained within abdomen. Operation through left flank, the size of patient requiring the introduction of the entire hand into the abdomen in order to reach the right testis. Both testes were normal in size but soft and flabby. All four were castrated without anæsthesia, the abdominal incision was closed by skin sutures only, usual antiseptic precautions were observed and all recovered promptly without incident.

HYDROPS AMNII IN A COW.

(556) Occurring almost solely in the cow hydrops amnii presents an interesting problem in etiology, being so far without explanation.

The patient in question was a Holstein cow of medium size, 7 months pregnant, and had apparently gone well until 14 days prior to examination the owner noted unusual distension of the abdomen and was led to suspect twin pregnancy. She had not been grained but had plenty of grass and fodder and was in fair condition, and believing twin pregnancy to exist and parturition nearing, the owner began feeding a moderate amount of grain. The abdomen continuing to enlarge the owner became suspicious and gave one pound mag. sulph. without producing any change in the constantly increasing abdominal tension, the patient finally becoming unable to rise without assistance, though when up looked bright and ate and drank normally. Her inability to rise seemed more due to the excessive intra-abdominal weight than to any weakness of the patient.

Being called to examine the patient it required the aid of six men to get her on her feet, when she stood and walked well, though as if overloaded. Percussion and rectal exploration revealed hydrops amnii, and a trocar passed into the amnion through the right flank showed the fluid to be perfectly colorless and odorless, as usually observed in these cases. Twenty

gallons of it were allowed to run out through the canula. The os uteri was dilated, the membranes ruptured and the fluid left free to escape, the patient being now left for 24 hours, hoping there would be sufficient gradual dilatation of os to permit of easy extraction of the fœtus, which was at the date of examination still alive and vigorous in its movements.

On the following day the patient could rise with less assistance and had shown some slight labor pains; the os was moderately dilated, the fœtus dead and emphysematous and required considerable force for its extraction, after which the cow seemed much exhausted. A stimulant was administered, and the patient placed in comfortable quarters. Although much of the amniotic fluid had escaped through the os, a great deal remained, the long continued over distension having apparently produced uterine paralysis.

Three hours after removal of the fœtus the cow died from exhaustion.

The autopsy showed a very thin chorion and uterus, the body of which was practically obliterated, the hydrops having been confined to the two cornua.

This change in relation between uterus and cornua constituted an interesting feature in the case. When dilating the os at the time of the first examination, directly in front of the os, centrally located and perpendicular, was a thin band, the nature of which we failed to determine. The autopsy showed this to be the point of juncture between the two cornua which instead of being located several inches in front of the os intern, as in the non gravid or normal gravid uterus, was in direct contact with the os. The uterus was intact in every part except slight lacerations at the cornual juncture, which, however, were of no significance. There were no notable deviations from the normal observed in any organs, except the large flaccid uterus.

In a herd of 10 dairy cows the owner had lost one previous to the case here recorded, undoubtedly of the same affection and but two days prior to our visit.

The results in this case indicate that the proper method to

pursue, is to complete at once the dilatation of the os and evacuation of the uterine contents by physical force, and not leave this to be accomplished by labor pains after rupturing the membranes. Such a plan involves much time, labor, and patience, as the cow's os is so firm that it can not be rapidly nor easily dilated, but the uterine walls having been so over distended lose their power and fail to accomplish the purpose sought, while the flaccidity and fluidity tend to rapid and intense infection, with death of the fœtus and absorption of toxic substances.

Siphoning out the fluid after rupturing the membranes would doubtless aid in relieving the uterus and possibly aid it in contracting upon the fœtus. After the fœtus is properly secured by cords it would seem that the recumbent posture would be best for delivery, facilitating the exit of fluids and also the fœtus from the paralyzed uterus.

ASCITES IN A PREGNANT EWE.

(858.) An aged Shropshire ewe at full term of pregnancy had for some weeks shown a progressive distention of the abdomen and for a few days prior to presentation at the clinic had shown inappetence, debility, and difficulty in progression, owing largely to the immoderate distension of the abdomen. Hydrops amnii was at first diagnosed and an effort made to relieve the difficulty by rupturing the supposedly affected membrane through the os uteri, but the effort proving fruitless the patient was destroyed, and the autopsy showed that the fluid had been intra-peritoneal. The peritoneal fluid was pale, slightly turbid, and contained numerous shred-like masses of dirty grayish lymph floccules.

The intestines, mesentery, omentum, lungs, and liver were thickly infested with the degenerate capsules of the *Œsophagostoma Columbianum*. It would appear that the unusual number of these caseated nodules in the liver were the probable cause of the ascites, as a result of their interference with the hepatic functions.

The differential diagnosis between ascites and hydrops

amnii in the pregnant ewe offers peculiar difficulties. The heavy abdominal tunic excludes abdominal taxis, the rectum is too small for safe exploration per anum, and the vagina fails to offer special facilities. The exploratary trocar might give identical results in either affection, the fœtus in each case would tend to float upward, would generally be alive and vigorous, while percussion would reveal the same dullness in one case as in the other.

We find no record of hydrops amnii in the ewe, yet it is not impossible, as it has been recorded in the goat, though chiefly affecting cows.

The ewe will, in all probability, withstand laparotomy as well as the cow, in which case this one means for positive diagnosis is readily available, when if it proves to be ascites, the fluid can be drained away through the incision, while if hydrops amnii the incision can be closed, the os uteri dilated and artificial delivery brought about.

AMPUTATION OF OVARIES AND GRAVID UTERUS IN A BITCH.

(227) Patient, well-developed Collie bitch, æt. 8 months, procured by the present owner three weeks prior to presentation at the college clinic, was presumably non-pregnant. She had been fasted for 12 hours preparatory to spaying, which was undertaken by student H. by the flank method without anæsthesia. Difficulty was experienced in bringing up the uterus or other parts of the internal genitals and it was soon discovered that the uterus was gravid, requiring strong tension to lift the cornua up and out through the incision, when it was found that each cornu contained four fœtuses, which with their envelopes measured 2½ x 4 inches each, the eight fœtuses in the now exposed cornua representing a mass of near ½ gallon. The round ligaments of the ovaries were ligated with catgut, another ligature being placed about the cervix uteri, the entire mass, ovaries, cornua, uterus, and broad ligament were removed and the flank incision closed by deep sutures. On the following day the patient looked bright, but lay quietly and refused food; on the second day the general appearance was better and appetite

fair, the animal taking some milk, and on the third she seemed quite well, moving about freely, had a good appetite and was apparently convalescent. The wound showed slight but unimportant infection and the patient was permitted to be removed, after which recovery progressed without incident.

COMPOUND FRACTURE OF METATARSUS IN A DOG.

(133) The patient, an adult Collie, had engaged in a fight with another dog about three weeks prior to presentation, during which compound fractures of the right metatarsals were produced at the lower third, probably by a bite. The owner failing to secure recovery the patient was submitted for examination, and it was found that the fractured ends of the bones moved freely on each other, while they communicated with the exterior by two fistulæ opening on the median side of metatarsus, from which considerable pus was discharging.

The injured member was fixed by means of plaster of Paris bandages, the fistulous openings being marked by a cork, which was later cut out and the fistulæ dressed with solution of carbolic acid, followed by powdered iodoform, the dressing being retained by means of a bandage with equitable pressure. The dressing was repeated once daily for six days, at which date the suppuration had virtually ceased and the patient was discharged, with directions for the continuation of the dressing, and recovery progressed rapidly without further incident.

PIERRE AUGUSTINE FISH, D.Sc., D.V.S.,

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ARTICLES.

Zoophily versus Homophily.
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ZOOPHILY VERSUS HOMOPHILY.

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The onward march of events, accompanied by new conditions and new methods, has given a much wider significance to the term vivisection than was formerly attached to it. It is quite commonly regarded, by those opposed to the practice, as a method of inflicting, by dissection upon a living conscious animal, excruciating pain for the gratification of the operator's curiosity, or for the exhibition of some experiment already demonstrated and thoroughly familiar.

Technically a man or animal is vivisected when a hypodermic needle is thrust into the skin for the purpose of alleviating the pangs of disease by this form of medication ; while if any part of the body be crushed or mangled by a blow, as from a club, resulting in serious injury, there is infinitely more suffering but not literally vivisection, since the tissues are not cut but bruised. Nor is the condition of the victim taken into account ; a serious and prolonged operation upon an anesthetised animal may result in as little discomfort to it as the blows or accidental injuries received by any dog on the streets as an incident in his career ; or, in the former case, if the operation result in death, the end is without pain.

But the issue that now seems to be nearest the surface, under this really comprehensive term of vivisection, is whether it is justifiable to utilise, even to their destruction, animals for the real or probable benefit of mankind, and with this as the issue, there would be the natural classification of those who, influenced by genuine sentiments of mercy and a desire for the alleviation of suffering, band themselves together for its suppression, especially in animals, on account of the inability of the dumb beasts to make known certain existing

abuses and because of their helplessness in competition with men. This class of persons would encompass the animals with so many and rigid safeguards that if really put into practice many lines of progress would be materially restricted. For our present purpose let such persons be classified as Zoophiles—antivivisectionists—and the vivisectionists as Homophiles, the latter advocating not only the essential doctrines of the former but something more. Actuated by the same sentiments of mercy and regard for suffering they would, when obliged to inflict pain for the general good, minimise it to the greatest possible extent, by the use of anesthetics or otherwise.

The practice of vivisection, like the theory of evolution, does not appeal to the finer esthetic qualities of mankind; it is not intended to; it would appeal rather by an array of self-evident facts to the importance and necessary usefulness of the practice.

Is it justifiable to sacrifice an animal from a lower level in the zoological scale for the preservation or benefit of another animal in that same scale? Nature has already decided that question by the creation and maintenance of the order of carnivorous animals, which live on flesh alone, and others which subsist on mixed diets. If the zoophiles understood and were enabled to trace the preparation of their animal food from the living creature to the time it is ready for eating, would they still exercise as much pertinacity in their denial of the right to use lower forms for the benefit of the higher, or is Nature again at fault in fashioning the human digestive apparatus so that a mixed diet may be enjoyed? Would not a logical adherence to their cardinal principles preclude anything but a vegetable diet, and extend even to the matter of clothing and personal adornment?

But the answer is made that it is not the aim to legislate against animal inoculations for the determination of disease, but to supervise and to eliminate the promiscuous and unnecessary use of it. Much stress is also laid upon the tortures which have been inflicted upon animals in the past, and these remote

instances, although exceptional when the vast number of experiments are considered, are resurrected and represented as being in common usage at the present day. There is no practice that may not be abused. Are the principles of the Christian religion, upon which so large a portion of the civilised world depends for encouragement and support during the battle of life, to be undermined because long years ago there were certain enthusiasts whose zeal permitted them to inflict the most excruciating, cruel and unparalleled tortures upon their fellow-beings "In His Name"? Is the future saving of human life, the saving of vast sums of money by the preservation of the lives and eradication of disease in domesticated animals, and the search for the truth which elevates to a higher plane of civilisation to be retarded by the misdeeds of past offenders? Will statistics confirm the generalised statement that vivisection tends to brutalise the operator? Such an accusation is not brought against a surgeon in the performance of his duties. Wherein lies the great difference in the degree of vivisection? How many of the antivivisectionists have really gone beyond the first shudder at the thought of the existence of pain and appreciated the fact that life itself is a struggle for existence, and that the perception of a greater or less amount of pain, under ordinary conditions, is a circumstance in the career of every living creature?

The vivisecting experiments of Galvani have illumined not only the scientific world, but the material world as well. Out of the crude apparatus of a vivisector have been developed the wonderful electrical appliances of today. Galvani's experiments were the keys which unlocked the doors of ignorance, not only as to certain physiological phenomena, but the manifold mysteries of the uses of electricity, many of which are still unsolved.

The fact that mature and deliberate judgment may be exercised in a question of such vital interest has been recently exemplified in one of the Cantons of Switzerland, where a measure for the total prohibition of vivisection was submitted

to the population *ad referendum*, with the result that 40,000 votes were cast against such prohibition and only 17,000 for it.

In the District of Columbia, it has been proposed to legislate against vivisection, or, at least, to regulate it by the maintenance of certain inspectors, who shall at intervals visit the laboratories or other places where the practice is carried on.

The bill as arranged is unnecessary, unreasonable, retrogressive and reactionary in its tendency.

It is unnecessary, because the great majority of vivisectors are intelligent, earnest and humane gentlemen, whose object in animal experimentation is to suppress and prevent the occurrence of disease, or to add some new fact for the welfare of mankind.

It is unreasonable, in that it advocates a system of espionage in which the inspector may be a person ignorant, unskilful and unappreciative of the object to be investigated or of the methods employed therein. It is manifestly unfair to permit such a person to officiate as censor, and is a malicious insinuation against the integrity of the investigator.

It is retrogressive, because it prevents further research; medical and biological sciences can progress only through experimentation.

It is reactionary, because in the effort to encompass the animals with so many safeguards their use for the real benefit of mankind is lost sight of, and one should be reluctant to assume that the antivivisectionists love animals more and their fellow-beings less.

Pain is an adjunct of life, and its merciful infliction upon lower forms is not only justifiable but necessary when it may alleviate human suffering. Humanity is above animality and as long as Nature endows living animals with sensitive tissues, just so long will pain exist.

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NOTES ON TECHNIQUE.

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In many of the modern articles, the methods by which certain pathological structures are demonstrated, if mentioned at all, are frequently so meager in the description of important details as to be practically useless to many workers, unless a certain amount of their time is devoted to experimentation. A person, who has obtained fairly successful results with his older methods, is loath to forsake them, especially if his first few attempts with the new are failures. Each investigator may have certain laboratory conveniences; reagents of the best quality and dyes that have been well tested, all of which will enable him to obtain results much superior to his less fortunate colleague. It is difficult, therefore, to work successfully unless details are carefully attended to, and the reasons for the various steps understood. The methods following have been well tested, and have been attended with uniformly good results, which in some cases, it is believed, would have ended in failure with the older methods.

FIXATION.

The fixation of pathological tissues, with strong alcohol for histological study, is very commonly employed for the double purpose of killing at once any microörganism that may be present and at the same time to preserve the structure of the part. With many tissues this caused a too rapid withdrawal of the contained water or lymph, so that the specimen becomes hard and gives unsatisfactory results when it comes to the cutting process.

Some experiments with different reagents, upon known pathological material, were of service in formulating a mix-

ture, which obviated the defects of strong alcohol when used alone. This mixture, while quickly killing the bacteria, also preserves most faithfully the histological structure. Various solutions of formalin, including the undiluted, were employed, and gave good results, particularly the presentation of the bacteria, after the usual staining methods. The tissues were more or less swollen by the weaker solutions, in marked contrast to the contraction caused by alcohol. Various combinations of formalin with alcohol were also tried, and that which seemed to be most completely satisfactory for quick penetration and convenience, bacteriologically and histologically, was as follows :

95 per cent. alcohol	100 parts.
Commercial formalin (40 per cent. formic aldehyde) .	10 parts.

Pieces of tissue, $\frac{1}{2}$ centimeter square, are well fixed in from twelve to twenty-four hours, after which it is well to leave for a few hours in 95 per cent. alcohol before clarifying for the paraffin bath. Specimens, transferred directly from the fixing mixture, have been clarified in chloroform or cedar oil, but it requires a longer time.

The addition of the formalin is advantageous, because in a way it brings about a state of equilibrium. The alcohol alone shrinks the tissue, while on the other hand formalin swells it, so that in this respect the one reacts against the other.

ADHESION TO THE SLIDE.

After the infiltration and imbedding of the tissue in paraffin, the question of the treatment of the sections is one of some importance. If they are to be carried through a series of reagents in watch glasses, and not placed upon the slide until they are mounted, the sections must necessarily be rather thick, in order to withstand the manipulation. Very much thinner sections, if adherent to the slide, and consequently supported by it, can be carried through the different steps of the process without injury, and show the structural elements to much better advantage.

The albumen or collodion adhesive, usually employed for this purpose, however, possesses the disadvantage of taking the aniline colors used in bacteriology, sufficiently to disfigure the preparations. If a clean slide be coated with a thin film of glycerine and then rubbed very nearly dry with a cloth or the hand, and a drop or two of 35 per cent. alcohol be placed upon it, the section, if curled, will tend to flatten itself when placed on the alcohol. If the slide now be placed in a thermostat for a few hours, at a temperature near the melting point of paraffin, the heat will cause any wrinkles or irregularities of the section to disappear; the alcohol slowly evaporates and when the slide is thoroughly dry the albumen molecules of the tissue adhere quite firmly to the slide, as noted by Gaule. After this the slide may be heated gently over a flame until the paraffin begins to melt. If any moisture remains the section will be quite likely to loosen during the latter stages. Thick sections do not adhere so firmly as thin ones. The slides may then be immersed in a jar of turpentine or any solvent of paraffin and carried through the various grades of alcohol to water.

A shorter method, in which there is as firm adhesion of the section to the slide, is to bring the slide in contact with aniline oil for a few minutes after the treatment with the turpentine, absorbing the superfluous turpentine with filter paper. The aniline oil is also removed by means of filter paper. The section is then thoroughly washed in distilled water which removes the oil, and the tissue is then stained and washed in water. If aniline stains are used, a hurried rinsing is sufficient. Drain or absorb the water and again apply the aniline oil. Besides clearing the section the oil tends to remove the aniline stain and care must be exercised in not letting this process go to far. Displace the aniline oil with xylol and mount in balsam. The color ought not to fade if the aniline oil has been thoroughly removed.

With certain stains, or combinations of them, the aniline oil may not succeed in preserving the sharp definition of the color. Under such conditions the section, after staining,

may be treated directly with absolute alcohol to dehydrate and remove any superfluous stain. Some aniline dyes are not as soluble in absolute alcohol as in the weaker grades. Clear in xylol and mount in balsam.

The use of aniline oil in the treatment of the sections will be recognised as having been recommended by Weigert for bacterial purposes. It likewise gives most excellent results in ordinary histological work and is a saving of time and material.

MOUNTING.

Many valuable specimens are ruined for the want of sufficient precaution in the preparation of the balsam. In its commercial state it contains many volatile principles and traces of acids, which, in the course of time, act upon the specimen and diminishes or entirely removes the color. All this may be lessened, if the balsam be heated sufficiently to drive off the volatile constituents, or more thoroughly obviated if a little potassium carbonate or mild alkali be added to neutralise the acid just before the balsam is heated. When the balsam becomes hard it can be broken into flakes and stored. When wanted for use dissolve in xylol to the desired consistency and filter through absorbent cotton. Specimens stained with the Biondi-Ehrlich mixture (which fades so easily) have at the end of a year shown no signs of losing their pristine clearness.

NEUTRAL RED IN HISTOLOGY AND BACTERIOLOGY.

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Neutral red (*Neutralroth, rectif. nach Ehrlich*) in weak solutions of 1-10,000 or thereabouts, has been demonstrated to possess considerable efficiency in the staining of vital tissues, but some difficulty has been experienced in finding a trustworthy mordaunt to prevent the dye from washing out of the stained tissues too readily. For the study of living protozoa it has proven of considerable service, but for higher forms which must undergo killing, imbedding and sectioning, there have been manifest difficulties encountered. Quite satisfactory results, however, were obtained in the case of a tapeworm (*Dipylidium*) found in a dog. The living worm after an immersion of 12-15 hours in normal salt solution with enough of the neutral red salt to tinge the fluid, became markedly colored but somewhat shrunken owing to the difference in the temperature. In order to avoid the removal of the dye from the specimen and to prepare the tissue for the subsequent processes some of the segments of the worm were immersed in a 3 to 5 per cent. solution of formalin also tinged with the dye. After 12-24 hours the tissue was thoroughly fixed and there was no diminution in the color. The subsequent treatment was that as ordinarily employed for *in toto* staining. The superfluous stain was removed during the passage of the tissue through the alcohols, and the specimen, after dehydration and clarification was mounted in balsam.

Portions of the vertebrate nervous system have also been simultaneously fixed and stained *en masse* in the formalin-neutral red mixture, and, after imbedding in collodion or paraffin, have been sectioned and mounted with very satisfactory results. Section staining has also resulted very satisfactorily, if the sections are treated with absolute alcohol immediately after staining. With lower percentages of alcohol the color is generally all washed out by the time the tissue is dehydrated. The dye

is also soluble in most of the clarifying reagents, so that in order to obtain the best effects the absolute alcohol should be allowed to act only just long enough to dehydrate the tissue, then clarify with xylol (which does not remove the dye) and mount in balsam.

The dye seems to have an especial affinity for the chromatin of the cells, staining this substance more or less intensely and leaving the remaining tissue colorless. Under proper conditions it would seem as if it might exert some special action on the neutrophilous tissue elements.

In addition to its histological uses neutral red has been found serviceable for some bacteriological purposes. As the name indicates the salt is of a neutral character, and a trace of it in a small beaker of water causes the mixture to assume a pinkish color. This solution has been found useful as a test and a more delicate one than litmus paper for determining the alkalinity of culture media. If the media be acid or neutral there is no marked change in the red when a portion of the media is added unless there be a slight deepening of the pink color; but if the media be alkaline and a few drops be added to the neutral red solution and slightly agitated the mixture immediately changes to a brown color.

In aqueous solutions the neutral red, if treated with either sulphuric, hydrochloric or nitric acid, at first shows no change, but if a sufficient amount of either acid be added the color changes from red, first to purple and then to a deep blue. If acetic acid be added to the aqueous solution of the neutral red there is no change except perhaps a slight deepening of the color.

In an alcoholic solution, the neutral red presents a light brown or amber color; upon the addition of an alkali (sodium hydrate) this is not changed except for a general lightening of the color due to the dilution. If the alcoholic solution be treated with hydrochloric acid added in increasing quantities it changes first to a red and then to a light blue; if treated with nitric acid the solution changes to a red and then to a dark blue; if sulphuric acid be employed the change is first to a red and then to

a bottle-green color. Acetic acid changes the alcholic solution to a pinkish-red color.

As a result of these crude experiments, the idea quite naturally presented itself that the neutral red solution might be incorporated with the culture media and the reaction of the different bacteria observed directly during their growth. In the experiments which followed a number of micro-organisms were utilized among which were the following: bacillus choleræ suis, Proteus vulgaris and mirabilis, bacillus of diphtheria, bacillus fluorescens liquefaciens; bacillus anthracis; comma bacillus; bacillus typhosus; bacillus acidi lactici; staphylococcus pyogenes aureus and a yellow sarcina.

The report of the results is purposely crude and generalized. A few certain well known and representative forms carefully tested with the various media under different conditions would do much towards elucidating the possession or absence of specific chemical reducing powers.

In the preparation of the cultures a $\frac{1}{5}$ per cent. solution of the neutral red salt was used. This was thoroughly sterilized, and then with a sterilized pipette ten drops of the "red" was added to the already sterilized media (bouillon, agar, or gelatin). The proportion being approximately 10 drops of the $\frac{1}{5}$ per cent. solution of the red to about 8 cc. of the media. The resulting mixture was a bright garnet red color. Besides the ordinary tube and plate cultures, fermentation tubes containing glucose, saccharose and lactose were utilized. As in the case of the others, the neutral red was added to the already sterilized media; but on account of the admission of more or less air when the red and media were mixed, the fermentation tubes were again heated in the sterilizer and the bubble of air in the closed tube tilted out so that the reducing properties of the mixture might not be interfered with.

The results obtained, with the various media employed and the action of the different micro-organisms upon them, may be briefly summarized into two general classes of phenomena:

1. Those organisms which change the garnet red media to a fluorescent and then to an ultimate brown color.

2. Those which do not cause fluorescence nor change the red color except to deepen it.

In general the fluorescent and brown color indicate an alkaline reaction ; the red the presence of an acid or a neutral condition. Between these two groups some intermediate conditions may be found, as for instance, when the media may contain a greater or less amount of grape sugar, certain of the bacteria may give, at first, an acid followed by an alkaline reaction ; or an apparently opposite condition may be shown as in one case of the bacillus coli communis grown in a fermentation tube of glucose. There soon appeared the fluorescence but the litmus paper demonstrated an acid reaction, later the fluorescence disappeared and the characteristic red (acid) color returned.

The change of the red to the fluorescent and brown color is, in general, caused by the alkalinity ; but it will also be remembered that alcohol turns the red to a brown, and that with the proper conditions as to the presence of grape sugar and reaction of the bacteria, some alcoholic fermentation may be set up, which in the above mentioned case of the bacillus coli in glucose, may account for the unexpected fluorescence with an acid reaction and likewise be of some service as a test for alcohol.

When fluorescence does occur in the fermentation tube it is usually more distinctly shown in the closed tube than in the bulb. The greater volume of the fluid in the latter is perhaps the explanation for this.

Rather an unusual amount of crystallization developed in the agar and gelatin media. While this phenomena is not uncommon in these media as ordinarily used, the addition of the red seemed to develop the crystals quite constantly and in unusual quantities. They were quite inconstant as to color, size and form, in the different species and the variations met with in these respects, although perhaps of no use diagnostically, seemed, nevertheless, worthy of mention.

'94 Ehrlich. Ueber Neutralroth, *Zeit. f. wiss. Mikros.* XI.—250. [Abstract.] Aus dem Bericht "Uber dem Ehrlichschen Vortrag im Verein für Innere Medicin" zu Berlin 18/12, 1893. *Allgem. Med. Centralzeitg.* 1894. No. 2, p. 20.

'94. Galeotti Gino. Recerche sulla colorabilita delle cellule viventi. *Zeit. f. wiss. Mikros.* XI. 172-207.

THE BRAIN OF THE FUR SEAL, CALLORHINUS URSINUS; WITH A COMPARATIVE DESCRIPTION OF THOSE OF ZALOPHUS CALIFORNIANUS, PHOCA VITULINA, URSUS AMERICANUS AND MONACHUS TROPICALIS.*

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With Plates X to XIII.

TABLE OF CONTENTS.

Introduction, ... 58
Removal of dura, ... 59
Terminology, ... 60

Callorhinus ursinus, ... 61
Lateral aspect, ... 62
Mesal aspect, ... 66

Phoca vitulina, ... 68
Lateral aspect, ... 68
Mesal aspect, ... 71

Ursus americanus, ... 72
Lateral aspect, ... 72
Mesal aspect, ... 74

Zalophus californianus, ... 75
Lateral aspect, ... 75
Mesal aspect, ... 76

Fissural interpretations of other writers, ... 77
The lateral ventricle (paracoele), ... 78
Monachus tropicalis, ... 81
General considerations, ... 84
Description of plates, ... 91

*This article was written at the request of a member of the Bering Sea Commission and will appear in their Report of the Bering Sea Fur Seal Investigations.

INTRODUCTION.

The specimen was from a young male pup twenty five inches in length, weighing about twelve pounds. The brain was still incased in the dura and on the basal surface portions of the cranial bones were left adherent to this membrane. An occasional cut through the dura caused a protrusion or hernia of the cerebral substance.

The weight of the brain in the fresh condition, as reported by Mr. Lucas, was ten ounces and two hundred and forty grains. This included the dura with the attached cranial fragments.

The specimen was preserved in a "rather strong solution of formalin" and except for some swelling of the tissue and softening of the interior was in a very good condition. The bloating was indicated by the increased weight which, immediatly after the receipt of the specimen, Dec. 12, '96 was found to be 13 ounces, a gain of nearly three ounces, by the closure of the fissures and by the cerebral hernias. The weight without dura and attached fragments of cranial bones after preservation from Sep. 1 to Dec. 12 was 9½ ounces and 80 grains (avoir.). The lateral girth was 26 centimeters, the longitudinal girth with the oblongata cut off at an even level with the caudal surface of the cerebellum was 24 centimeters, being slightly less than the former. This may, perhaps, be accounted for, to some extent, by the tape resting slightly in the inter-cerebral cleft, and to the bloating, as this would affect the lateral rather than the longitudinal circumference.

The brain as indicated by the girth measurements was of a subglobular form slightly tapering at the ends and its outer substance though firm was not unyielding. Twenty four hours immersion in 95% alchol served to contract the nervous tissue sufficiently to open the fissures and yet to retain enough flexibility of their walls to permit of an easy examination of their

depths. In order to obtain the desired results, after photographing the dorsal and ventral surfaces of the entire brain, it was cut across and the crura cerebri or mesencephal, and the cerebellum and oblongata separated. The cerebrum was then divided by a section along the median line, separating it as nearly as possible into two equal halves.

Removal of dura. The falx showed an interesting development, its frontal portion, especially in the region of the olfactory bulbs, being of considerable depth, then becoming very shallow along the middle of the length of the cerebrum and becoming very deep again in the intercerebral cleft in the caudal region of the cerebrum. A distinct longitudinal venous sinus as in the human brain is not present; but in place of it is a vein of some size lying to the right of the (intercerebral) cleft and receiving the contents of the dorsal cerebral veins. In connection with the weak development of the falx along the middle of its length, there was noticed an interdigitation of the gyres of the mesal surface of the hemicerebrums in this region. This intimate overlapping of the gyres on the mesal surfaces of the two hemicerebrums is possibly correlated with the deficiency of growth of the falx here and may serve, in a measure, to increase the firmness of the union of this region and prevent any undue strain upon the callosum which lies some little distance from the dorsal surface of the cerebrum.

This interdigitation of the mesal gyres is also present in the sheep where the falx is also deficiently developed. If the hemicerebrums be divided with a sharp knife without first separating the pial adhesion of the gyres, the gyres will be cut. An artifact of this nature has, indeed, been mistaken by one writer in an article on *Phoca*, for the cut surface of a bundle of fibers dorsal to and larger than the callosum and designated by him as the commissura suprema.

The tentorium in *Callorhinus* is very strongly developed, apparently extending the whole depth of the transverse arch-like cleft between the cerebrum and cerebellum. The tough fibrous tissue of the tentorium is, moreover, very noticeably reinforced by the presence of osseous tissue. Where the falx

joins the tentorium there is an extension of this osseous tissue in a vertical direction into the falx, a circumstance which certainly is not common in the majority of other animals but has been noted by Turner in *Macrorhinus*.

Terminology. With the existing uncertainties relating to the homology of the fissures of the brains of the carnivora and that of the human species, much confusion has resulted in the present nomenclature. Some have made a direct homology, others have proposed a fissural type solely and only for the lower forms, while still others have blended the two and some have utilized a system of names devised by themselves. On the lateral surface of the various fissured brain types there is at least one fissure—the Sylvian—which is quite constantly present, and on the mesal surface, the hippocampal fissure.

In the matter of nomenclature no attempt has been made to follow the law of priority, but those fissural names, whether of old or recent date which seemed most appropriate concerning position and relation, have been adopted, and, with perhaps but one or two exceptions, no new names have been introduced. It has been the purpose to use an intrinsic terminology and to substitute for the sometimes indefinite terms, anterior, posterior, superior and inferior, terms of more universal applicability, cephalic, caudal, dorsal and ventral. For cephalic and caudal Professor Wilder has recently suggested praeal and postal as equivalents, and for cephalad and caudad, praead and postad.

Where certain of the fissures or gyres have been submerged for a portion or the whole of their course, they have been designated as such, or the equivalent terms, subfissure or subgyre proposed by Wilder, have been used.

In the study of fissures mere surface appearances are not accepted as final. A fissural entity is not always easy to define. The best apparent guide is the relative depth throughout the course of the fissure. We may commonly assume that the greatest depth is at about the middle of its length and that it becomes gradually shallow toward each end until it reaches the surface. Such a simple condition, however, does not usually exist. One fissure may join the end of another, giving the ap-

pearance at the surface of a long continuous fissure. By separating its walls or "sounding" its depth the true state of affairs is easily perceived. The presence of a shallow whether it be near or at a distance from the end of a fissure would seem to indicate that at some time during development this shallow has been or will be represented at the surface and separate two independent fissures.

CALLORHINUS URSINUS.

Cranial Nerves. The cranial nerve roots of *Callorhinus* are well developed and need no special comment. In the case of the optic nerves we do not find the X-shaped chiasma as in *Phoca,* but the nerves run parallel to each other for a short distance from the chiasma before diverging toward the eyes.

The third pair or oculomotor nerves have a straight lateral direction from their apparent origins, but at the lateral border of the hypophysis they bend abruptly upon themselves and proceed cephalad forming a very distinct right angle.

The olfactory lobes are fairly well developed.

Fissures. No special mention will be made of the gyres (convolutions). These are naturally formed by the fissural depressions and it is believed that a careful description of these furrows will by implication include that of the gyres sufficiently for our present purpose.

The olfactory fissure is completely hidden by the olfactory crus and bulb; when these are removed a shallow fissure is apparent which becomes deeper toward the base of the lobe.

Forming the lateral boundry of the olfactory lobe is the rhinal fissure which passes in a caudo-lateral direction to the Sylvian. An apparent continuation of the rhinal from the Sylvian is known as the post-rhinal fissure. It extends in a meso-caudal direction for a centimeter and a half, stopping just short of the cleft between the cerebrum and the cerebellum. A careful examination of the postrhinal shows that it has no connection whatever with the rhinal but is continuous, superficially at least, with a subfissure (postica ?) lying in the caudal wall of the Sylvian.

Lateral Aspect. The Sylvian is a convenient fissure to begin with. There is usually some evidence of it if the brain is at all fissured, and in the lower animals, at least, it forms a center around which other fissures are more or less regularly arranged. In *Callorhinus* the Sylvian extends in a dorso-caudal direction, inclining somewhat toward the vertical. Apparently it terminates in a fork, but when the walls of the fissure are divaricated it is seen that the cephalic or anterior branch is really another fissure, which, after its superficial union with the Sylvian, becomes a submerged fissure lying just beneath the surface of its cephalic wall and running parallel with it to the base of the brain, but not actually connecting either with the Sylvian or with the rhinal. The Sylvian on account of the subfissural complication appears to be a larger fissure than it really is.

In a former paper[1] attention was called to the fact that this vertical fissure (superficial vertical branch of the Sylvian) had been mistaken for the true Sylvian. Both fissures are well marked and cannot be ignored, but it is an unusual circumstance for the Sylvian to assume a strictly vertical position in the adult and there would, moreover, remain a fissure in the usual situation of the Sylvian unaccounted for. In my former paper I designated this vertical fissure as the Anterior of the Felidae, and found at a later date, while consulting Krueg's article[2] that he questioningly represents a similar fissure by the same name in *Calocephalus* (*Phoca*) *vitulinus*. *Callorhinus*, while showing this fissure similarly situated, instead of elucidating the complications, seems rather to add to them and to suggest a probable doubt as to the correctness of the homology with the anterior fissure. Indeed, the conditions are strongly suggestive of its being nothing more than the detached frontal portion of the super-sylvian fissure. An examination of the brains of certain bears tends to illuminate this view. In the family *Ursidae* as

[1] '96. P. A. Fish. A note on the Cerebral Fissuration of the Seal (Phoca Vitulina). Jour. Comp. Neurol. VI, 15-19.

[2] '80. J. Krueg. Ueber die Furchen auf der Grosshirnrinde der zonoplacentalen Säugethiere. Zeit. f. wiss. Zoologie, XXXIII, 595-672, 5 plates.

in the *Canidae* the super-sylvian forms a complete arch, the caudal portion being known as the posterior supersylvian (Krueg), or postsylvian (Owen). The frontal portion of this arch varies in its distance from the Sylvian. Occasionally the frontal and caudal portions are about equally distant, but when there is any difference in this distance, it appears that the frontal portion approaches more closely to the Sylvian than does the caudal. In *Ursus arctos*, or the brown bear, Krueg figures the frontal portion of the supersylvian as approximating very closely to the Sylvian. The condition in *Callorhinus* might be considered as a stage just beyond this. In the brown bear the frontal portion of the supersylvian is still visible upon the lateral surface close to the Sylvian. In the case of the seal it has passed over the brink, so to speak, and is no longer visible its entire length on the lateral surface. The following diagrams will illustrate the conditions more clearly.

Fig. 1.

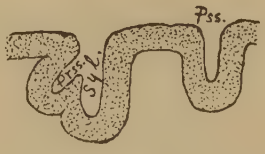

Fig. 2.

Figs. 1 and 2. A diagrammatic representation of the relation of the Sylvian and supersylvian fissures in the bear and seal, as if seen in section. *prss*, presupersylvian. *pss*, postsupersylvian. *Syl*, Sylvian fissure.

At the bottom of the Sylvian fissure lies the insula, presenting but a slight degree of development. There is a suggestion of a circuminsular fissure but in other respects the surface is entirely smooth. In the caudal wall of the Sylvian is a well marked subfissure. It separates a portion of the concealed cortex, forming a subgyre, which from its size and position might be easily mistaken for the insula. The appearances would suggest that the subfissure is the postica and the subgyre a remnant of the Sylvian gyre.

The supersylvian fissure shows some variation on the two sides. It presents the usual arrangement on the right hemicebrum, forming, superficially at least, a complete arch around

the Sylvian. The presence of a shallow and a slight bifurcation near the level of the free end of the Sylvian indicates the separation of a postsupersylvian fissure, postsylvian of other writers. Plate I, Fig. 4. The supersylvian curves around the free end of the Sylvian at a rather sharp angle and soon apparently enters the Sylvian, but in reality is submerged in its cephalic wall. A very short cephalic branch is given off toward the ansate fissure before the supersylvian enters the Sylvian. On the left hemicerebrum there are three distinct portions; the postsupersylvian has a slightly more oblique dorso-caudal course, the supersylvian proper is quite branching and more inclined to a vertical than a horizontal course. One of its branches appears to enter the Sylvian from behind but a shallow shuts off any deep connection. The frontal portion appears as a surface fissure for only one third of its course, then, as on the other side, it becomes submerged in the Sylvian. As this portion bears much the same relation to the supersylvian as the postsupersylvian whether they be disconnected or not, the frontal portion will be designated as the presupersylvian fissure. In the second specimen of the brain of an adult *Callorhinus*, kindly loaned to me by Mr. True, the executive curator of the U. S. National Museum, both hemicerebrums showed a distinct separation of the postsupersylvian, more pronounced than on the right hemicerebrum of the pup; but there was no separation nor distinct appearance of a shallow indicating an independent presupersylvian as in the left hemicerebrum of the pup. In the adult, as in the pup, each supersylvian gave off a short cephalic branch before entering the Sylvian.

The Lateral fissure, on account of the breadth of the brain, does not show in its entirety upon the lateral aspect. It is twelve centimeters long, by far the longest fissure, and is seen for a short portion of its course upon the ventral aspect extending, on the left hemicerebrum, to within five millimeters of the ventral portion of the postsupersylvian. It lies in this region just in advance of the margin of the cleft between the cerebrum and the cerebellum. It then arches caudo-dorsally approximately parallel with the hemicerebral margin but receding from

it until it fully reaches the dorsal surface, then approaching to within eight or nine millimeters of the intercerebral cleft, it continues its arched course in a cephalo-ventral direction approaching to within five millimeters of the presupersylvian fissure at about the level where the latter becomes submerged in the Sylvian.

The lateral is a deep fissure and no distinct evidence of shallows could be detected along its course although in certain places the presence of submerged buttresses interfered to some extent with the soundings, the average depth being from ten to thirteen millimeters. The cephalic extremity of the fissure terminates in a fork, more marked on the left hemicerebrum than on the right. Does this widely forked termination represent the ansate fissure? It has the same appearance and relation to the lateral as seen in the cat, and provisionally, it is here so designated.

The gyre, bounded by the lateral and supersylvian fissures and its parts, is indented by numerous branches originating from the above named fissures. There are also occasionally independent minor fissures present in this gyre.

The Ectolateral fissure. The ectolateral on the right hemicerebrum is a distinct fissure. It begins on the ventral surface near the termination of the postrhinal; it then proceeds dorso-caudally, parallel with the postsupersylvian and for about the same distance. On the left side it is a shorter fissure and superficially is continuous with the dorsal portion of the postsupersylvian but a shallow separates a deeper connection. On the left side side of the adult *Callorhinus*, a somewhat similar condition exists except that the superficial union of the ectolateral is with the ventral portion of the postsupersylvian.

The Coronal fissure is about three centimeters in length and extends except for a slight caudal convexity in an almost vertical (dorso-caudal) direction. Its greatest depth is eight millimeters. On the right hemicerebrum it gives off a slight spur pointing toward the Sylvian. In *Callorhinus* it represents, perhaps, the least complicated fissure in the brain.

The Cruciate fissure is not at all represented upon the me-

sal surface of the brain. It is seen best from a dorsal view. It arises at the margin of the intercerebral cleft. It arches in an obliquely cephalo-lateral direction. From the cephalic extremity of the cruciate at a depth of fifteen millimeters there passes off another fissure, which Krueg has represented as the precruciate in certain carnivora, nearly to the mesal margin just dorsal to the olfactory bulb. The depth of these fissures at their junction is from 12-15 millimeters. Between these fissures and the intercerebral cleft there is a triangular shaped area to which Mivart has applied the name of "ursine lozenge" (Turner), thought by Mivart to be of considerable significance. Just caudal to the cruciate fissure is a small fissure corresponding to the postcruciate of Krueg. On the left hemicerebrum it is triradiate, on the right it is straight.

The Superorbital fissure has no connection with the rhinal. Its length is 25 millimeters and its depth 8-10 millimeters. It has a slight lateral convexity but has no branches.

The Medilateral fissure. The name of this fissure is particularly appropriate in *Callorhinus;* not only is it on the mesal side of the lateral fissure, but for a portion of its course is actually on the mesal aspect of the brain. It curves around the caudal margin of the hemicerebrum just on the verge of the cerebrocerebellar cleft. Between the lateral and medilateral fissures there is a gyre averaging about 15 millimeters in width in which there are two or three secondary fissures, which would seem to indicate an attempt at the division of this gyre into two.

Mesal Aspect. The callosal fissure presents no marked peculiarity except upon the left hemicerebrum where, instead of continuing around the genu of the callosum, it proceeds toward the dorsal margin, or is continuous with a fissure coming from this margin. On neither hemicerebrum is there any appearance of a fissure immediately surrounding the genu. The hippocampal fissure occupies its usual position, arching from the splenium around the optic thalamus to the tip of the pyriform or temporal lobe.

The Splenial fissure. On the right hemicerebrum, this fissure, if prolonged on the dorsal aspect, would be continuous

with the cruciate. It is separated by a gyre 4 millimeters in width. The fissure passes ventro-caudally and a little beyond the splenium on the ventral aspect and it apparently terminates in a wide fork, or else enters a fissure passing at right angles to its own course. Sounding the fissure at this point gives some indication of a shallow separating the caudal branch of the fork. Following the appearance designated by Krueg in his diagrams of the conditions found in some of the carnivora, the splenial proper includes the ventral branch of the fork, while the dorsal branch may represent what he calls the postsplenial. On the left hemicerebrum the splenial fissure penetrates the hemicerebral margin and appears for a short distance on the dorsal surface. A smaller but well defined fissure lies in front of the splenial. On the left side it cuts the dorsal margin. For the present we may designate it as the presplenial fissure. It corresponds very well with the fissure which Kükenthal has called fissura sublimica anterior.

The Marginal or supersplenial just passes the meso-ventral margin of the hemicerebrum about ten millimeters caudad of the splenial. It extends approximately parallel with it to the dorsal margin which it cuts and on the right hemicerebrum extends on the dorsal surface for about 15 millimeters. On the left hemicerebrum the fissure branches just at the margin. The main portion however continues obliquely latero-cephalad for about 20 millimeters. In the gyre between the splenial and supersplenial fissures a well represented secondary fissure is seen.

A well defined but unnamed fissure lies on the meso-ventral surface. It arises at the caudal margin and proceeds in an angular course toward the ventral end of the splenial, it then swerves cephalo-laterad and terminates not far from the postrhinal. Its position corresponds approximately to the collateral fissure in the human brain. This tentorial surface of the cerebrum has numerous secondary fissures and branchings some of which seem large enough to merit special mention. One such fissure lying parallel with the postsplenial suggests a similarity to the occipital. It cuts the hemicerebral margin slightly and the relation of the lateral fissure at this point suggests in a way

the paroccipital of man. This occurs on the left hemicerebrum. On the right the postsplenial has much the same appearance.

At the cephalic end of the mesal surface beyond the genu of the callosum, there are two pretty well marked fissures. The one nearest the callosum corresponds to the genualis of Krueg, part of falcial—Owen, or falcial—Wilder. On each hemicerebrum this fissure cuts the dorsal margin slightly. The other and more slightly developed fissure lies nearer to the olfactory bulb. It does not reach the dorsal margin but extends farther in the ventral direction. This fissure corresponds to the rostralis of Krueg, part of falcial—Owen, subfalcial—Wilder.

PHOCA VITULINA.

The frontal portion of the cerebrum is more foreshortened than in *Callorhinus* and there is therefore a slightly different arrangement of corresponding fissures in that region. One of the most striking differences is the olfactory portion of the brain. In *Callorhinus* it is the larger, the olfactory bulb is of considerable size, the crus is correspondingly wide and lies flush with the mesal surface. In *Phoca* the bulb is relatively smaller and the crus has atrophied to scarcely more than a pedicle, it lies deeply imbedded in the olfactory fissure and it is removed 6-8 millimeters from the mesal surface by a portion of the cortex which projects fully 5 millimeters beyond the crus.

The precribrum (anterior perforated space) is well developed and shows with greater distinctness than in *Callorhinus*. The rhinal fissure is apparently continuous with the Sylvian, but upon raising the overlapping portion of the frontal lobe, it is seen to maintain its continuity and to appear again caudal to the Sylvian as the postrhinal, differentiating a larger pyriform lobe than in the case of *Callorhinus*. There is no connection between the postrhinal and the subfissure in the caudal wall of the Sylvian as in *Callorhinus*.

Lateral Aspect. The Sylvian fissure pursues a much more obliquely dorso-caudal course than in *Callorhinus* and presents the same amount of complexity with relation to the surrounding fissures. In its caudal wall lies a subfissure (postica ?) and

the intervening Sylvian gyre. Both are relatively better developed than in *Callorhinus*. The supersylvian has much the same relation to the Sylvian as in *Callorhinus*. It is not distinctly separated from the postsupersylvian although the interlocking of some of the subgyral buttresses suggests the possibility of an attempt at separation. On each hemicerebrum there is a continuation of the postsupersylvian dorso-caudad beyond the supersylvian.

Fig. 3.

Fig. 4.

Fig. 3. Cross section of a fissure, showing the obliquity of the walls.

Fig. 4. A diagram to show the difference in the course of a fissure at its surface and depth. The heavy lines represent the fissure walls at the surface. The dotted lines and arrows represent the buttresses (b) formed by the bulging of the deeper portion of the wall of the fissure.

The frontal end of the supersylvian apparently forks, one branch bending toward the Sylvian, the other continuing cephalad. The ventral branch has a superficial union with the vertical fissure which has been mistaken for the Sylvian. In my former paper (l. c.) I designated this fissure as the anterior. Krueg also had taken the same view. From the conditions already described in *Callorhinus*, it seems to me that this fissure is after all a disconnected portion of the supersylvian and that presupersylvian would in some ways be a suitable name for it. It is submerged in the cephalic wall of the Sylvian for the ventral third of its course. In *Callorhinus* the ventral two-thirds of the corresponding fissure becomes submerged.

The lateral fissure, as in the case of *Callorhinus*, is the longest fissure in the brain. In *Phoca*, however, it is confined entirely to the dorsal aspect of the cerebrum, and at its caudal end it appears to terminate in a widely diverging fork or perhaps a small transverse fissure, possibly corresponding to the lunate (Wilder) of the cat. Its course is approximately parallel with the intercerebral cleft and is somewhat tortuous. At

its cephalic end it appears to communicate with the cephalic branch of the supersylvian. This appearance will be discussed more fully under the description of the ansate fissure.

The ectolateral fissure occupies a relatively higher or more dorsal and caudal position than in *Callorhinus*. It is of a more secondary character and courses approximately parallel with the postsupersylvian.

The cruciate, unlike that of *Callorhinus*, is represented upon both the mesal and dorsal aspects. On the left hemicerebrum a shallow is present in the dorsal portion not far from the margin. No distinct "ursine lozenge" is present here as in *Callorhinus*. The foreshortened condition of this region may have something to do with its absence.

A well defined postcruciate fissure is present on the left side. It presents a zygal (Wilder) or quadriradiate form. A slight secondary fissure near the olfactory bulb may represent a rudimentary precruciate fissure.

The superorbital fissure shows a better development than in *Callorhinus* and similarly has no connection with the rhinal. But the opposite end, dissimilarly, extends farther and is overlapped by the olfactory bulb.

The medilateral is not present in *Phoca* as a distinct fissure. Its location is occupied by a series of short disconnected fissures.

The coronal fissure is a relatively longer fissure than in *Callorhinus* but is not so entirely disconnected from adjacent fissures. Its dorsal end lies caudal to the cruciate. On the left hemicerebrum it is separated by a shallow from an apparent connection with a continuation of the cephalic branch of the supersylvian. On the right hemicerebrum the shallow is suggested by the interlocking at this point of two submerged buttresses.

The ansate fissure, while not distinctly represented as an independent fissure, would, it seems to me, be indicated by the fissure extending from the coronal to the cephalic branch of the supersylvian, where, on each hemicerebrum, the interlocking of submerged buttresses would again suggest a shallow shutting it

off from the branch of the supersylvian, and then continuing to the lateral fissure where a slight spur pointing toward the intercerebral cleft might indicate its separation from the lateral. Owen in his figure of the hemicerebrum of *Phoca* represents a corresponding fissure as the coronal.

Mesal Aspect. There is a slight appearance of the callosal fissure in the splenial half of the callosum, but none at all for the remaining half.

The hippocampal fissure is well developed and needs no special comment.

The splenial fissure is well developed and in general is as described for *Callorhinus*, except that its position is farther removed from the frontal portion of the cerebrum and that its cephalic end cuts the margin and is shown upon the dorsal surface. The postsplenial has about the same relations as in *Callorhinus*.

The fissura sublimica of Kükenthal[1] is poorly represented in my specimen of *Phoca* and is somewhat confused with smaller branches and secondary fissures. It lies between the splenial and the callosum. Kükenthal finds this fissure also present in *Phoca groenlandica*, *Phoca barbata*, *Macrorhinus leoninus* and *Otaria jubata*. In *Callorhinus* there was no appearance of this fissure whatever. The fissura sublimica anterior of the same author is more clearly represented. In my former paper, on account of its position dorsal to the callosum, I designated it questioningly as the supercallosal. On the left hemicerebrum it is well developed and connects with the cruciate. On the right side, however, the fissure is independent and much smaller. In addition to this fissure, on each hemicerebrum, there is another dorsal to it and in front of the splenial. In *Callorhinus* I have called it the presplenial.

The marginal or supersplenial is well shown in *Phoca* as in *Callorhinus* but lies nearer to the dorso-caudal margin, approximately parallel with the splenial. In the intervening gyre there are a few secondary fissures.

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[1] Untersuchungen an Walthieren, 1889.

On the meso-ventral surface a fissure corresponding to the collateral is also present, but, unlike *Callorhinus*, it has connection with the postrhinal. Between the collateral and the postsplenial there is another well marked but unnamed fissure which is parallel to the former. It corresponds perhaps to the fissure in *Callorhinus* which I have spoken of tentatively in connection with the occipital.

The genualis and rostralis are represented but the latter differs from that in *Callorhinus* in being much less developed and occupying a more ventral position at a more or less acute angle to the genualis.

URSUS AMERICANUS.

This brain, while fairly well preserved, had been considerably mutilated in removal, so that for purposes of illustration and reference, a specimen from Ursus thibetianus, kindly loaned by Prof. B. G. Wilder,[1] was utilized; so that while the figures of the lateral and mesal aspects are from the latter specimen, the description is based almost entirely upon the former. The general arrangement of the fissures is similar and the minor details need not cause misapprehension. The fissural plan of the brain is much like that of the canine, minus the first circumsylvian arch.

The olfactory bulbs and crura are far superior in size to those of either of the seals. The olfactory fissure is likewise well marked.

The rhinal fissure passes into the Sylvian and continues, after forming an angle delimiting a well developed pyriform lobe, as the postrhinal and ending freely. The subfissure (postica?) in the caudal wall of the Sylvian extends to and, on one side, actually appeared to communicate with the postrhinal.

Lateral aspect. The Sylvian is directed in the usual dorso-caudal direction at the bottom of which is a small and simple area representing the insula. There is no appearance of a trans-

[1] Papers, chiefly anatomical, presented at the Portland Meeting of the A. A. A. S., August, 1873, are devoted largely to a description of the brains of Carnivora.

insular fissure although the presence of a subgyre and subfissure (postica ?) in the caudal wall of the Sylvian might superficially indicate it.

The supersylvian fissure forms a complete arch around the Sylvian. There is no indication of a separation of a postsupersylvian except near the free end of the Sylvian where a branch from the supersylvian extends into the adjacent gyre.

The lateral fissure forms a curve approximately parallel with the supersylvian. As compared with *Phoca* and *Callorhinus* it is much shorter. If the conception of the ectolateral is correct, the latter is continuous caudally with the lateral, a slight spur indicating the place of probable separation. The ectolateral extends parallel with the postsupersylvian but its ventral end does not reach so far in *Ursus americanus*, while in the Thibet bear the reverse is the case.

The ansate fissure is a cephalo-ventral continuation of the lateral, a small spur of the latter indicating a point of separation. The ansate describes a curve, the convexity pointing toward the Sylvian.

The coronal fissure continues from the ansate and ends freely near the superorbital. The convexity of its curve like that of the ansate points toward the Sylvian. The point of its separation from the ansate is indicated by a spur more marked than that between the ansate and the lateral.

The superorbital, unlike *Phoca* and *Callorhinus*, has a very distinct connection with the rhinal fissure at about half of the distance from the Sylvian fissure to the olfactory bulb. It curves cephalo-dorsad with its convexity pointing cephalad.

The cruciate fissure is more highly developed than in either of the seals. It appears slightly upon the mesal aspect and extends obliquely cephalo-laterad on the dorsal surface. Around its free end the coronal fissure demarcates a well-formed sigmoid gyre. The appearances found in *Phoca* approximate the conditions regarding the gyre more than in *Callorhinus*.

Between the cruciate and ansate lies the postcruciate fissure. On the left hemicerebrum it is well marked, on the right it is smaller and superficially connected with a minor fissure.

On the right hemicerebrum a branch is given off from the cruciate extending cephalo-mesad. It is the precruciate fissure. On the left hemicerebrum it is an independent fissure. In neither case does it reach the mesal surface. The precruciate with the cruciate forms a well-defined triangular area—the "ursine lozenge" of Mivart. On the dorsal surface between the lateral fissure and the intercerebral cleft there is a well marked fissure but it is not as deep as the other fissures. It is the confinis. On the right hemicerebrum a short fissure connects it with the lateral.

The medilateral fissure arises at the caudal end of the cerebrum near the mesal margin, in much the same position as in *Callorhinus* and continues down the ventral aspect close to the caudal margin.

Mesal Aspect. The splenial fissure does not reach the dorsal margin as in the case of *Phoca* and as on one side in *Callorhinus*. Its cephalic end is, also, nearer the caudal end of the cerebrum than in either of the other two forms. In this respect the fissure occupies an intermediate position in the *Phoca*. It arches around the splenium of the callosum and courses along the tentorial surface of the cerebrum as far as the caudo-lateral margin, ending eight millimeters from the free end of the post-supersylvian. Two or three short branches are given off along its course. Beyond the presence of a slight spur there is no evidence of a postsplenial fissure, nor of a supersplenial or marginal as in the case of the seals. A well developed presplenial or fissura sublimica of Kükenthal is present, resembling that of *Phoca* more than *Callorhinus*. No distinct fissura sublimica was present except in the case of the Thibet bear where a small minor fissure held the proper position.

The genual and rostral fissures were present and occupied the same general relation to the cephalic end of the callosum as in *Callorhinus*. The callosal and hippocampal fissures have the same general relations as in other forms.

ZALOPHUS CALIFORNIANUS.

Through the kind permission of Professor Wilder I was permitted to remove the brain from this young sea lion. Its mother came originally from the Pacific coast and the present specimen was found dead in the cage with her while in transit to the East and was presumably not far from "term." It measured 43 centimeters long and has been in the Cornell museum of Vertebrate Zoology for some years.

The brain was in a fairly good state of preservation and was photographed soon after its removal. It was too delicate to permit of much manipulation and some of the fissures were not sounded as thoroughly as in the other specimens. The cerebrum of this specimen does not show the same degree of complexity relative to the fissuration as indicated by Murie[1] in *Otaria jubata*. A direct comparison of the fissures, however, is not easy as the latter author attempts to homologize them with those of the human cerebrum.

The olfactory apparatus is well developed. Not as largely as in the bear, however, but greater than either of the seals. The rhinal fissure, as in the other forms, is well marked and passes caudad into the mouth of the Sylvian fissure. The postrhinal is formed from the subfissure (postica ?) and has no connection whatever with either the rhinal or Sylvian.

Lateral Aspect. The Sylvian is prominent and occupies its usual position. In its caudal wall is a subfissure (postica ?) and subgyre which as in *Callorhinus* is continuous on the ventral aspect with the pyriform or temporal lobe.

The supersylvian with its cephalic and caudal portions, the pre- and postsupersylvian, is more nearly in accord with the condition found in the bear than in either of the seals. It represents an intermediate condition between the two. The presupersylvian lies very close to the Sylvian but does not actually enter it as in the seals. Its average distance from it is about 4 millimeters; while the distance from the Sylvian to the post-

[1] 1874. Transactions of the Zoological Society of London.

supersylvian is four times as great or 16 millimeters. There is no sign of disconnection between either the supersylvian and the postsupersylvian, or the supersylvian and the presupersylvian. The supersylvian forks or sends out a branch cephalad connecting with the ansate fissure exactly as in *Phoca*.

The lateral fissure is relatively to the length of the cerebrum shorter than in any other forms. Its cephalic end and its relation to the ansate is again exactly the same as in *Phoca*. On the left hemicerebrum the lateral is disconnected at a little more than half of its length, by a narrow isthmus.

The coronal fissure corresponds with that of *Phoca*, connecting, superficially at least, with the ansate and thus indirectly with the cephalic branch of the supersylvian and the lateral.

The ansate fissure, as has already been intimated, like that of *Phoca* is irregular in its form and connects with the fissures above mentioned.

The ectolateral fissure is quite well down toward the ventral portion of the cerebrum and as in *Callorhinus* appears upon the ventral aspect.

The medilateral fissure is scarcely perceptible on the lateral aspect; it lies exactly along the caudal margin of the hemicerebrum as in *Callorhinus* and is better seen in a mesal view.

The cruciate accords, in position and relation, more closely with the conditions found in the bear and *Callorhinus*; but while it reaches to the mesal surface of the hemicerebrum it does not cut it as far as in the bear and *Phoca*.

The precruciate and the postcruciate fissures are likewise present and have exactly the same relations as in the bear and *Callorhinus*.

Mesal Aspect. The callosal fissure is well developed. On the right hemicerebrum it does not continue around the genu as in the left.

The splenial fissure does not extend as far cephalad as in *Callorhinus*, nor as far dorsad as in *Phoca*. It is situated more closely to the splenial half of the callosum than in either of the preceding or in the bear. A branch is given off in the region of the splenium proper which seems comparable to the

postsplenial in the seals. A slight spur in this region in the bear may indicate an analogy.

The presplenial is not represented as a distinct fissure on the left hemicerebrum, the only possible suggestion of it being a forking at the cephalic end of the splenial. On the right hemicerebrum a small but distinct fissure lying cephalad of the splenial may represent the presplenial.

The marginal fissure is well represented and on both hemicerebrums cuts the dorsal surface as in *Callorhinus*. In *Phoca* although relatively long it does not reach the dorsal margin at all. In the bear the marginal fissure is not represented.

The genual and rostral fissures are but slightly developed in this specimen and bear the same relations as in other forms.

The cruciate fissure shows slightly on the mesal aspect and in its relations to the other parts resesembles that of the bear more than any of the others.

FISSURAL INTERPRETATIONS OF OTHER WRITERS.

The Sylvian fissure, in *Phoca* at least, has been located as a vertical fissure (presupersylvian) which has, for a portion, only, of its length, been submerged in the cephalic wall of the true Sylvian. Numerous writers have also described this condition as the anterior and posterior branches of the Sylvian. The two fissures morphologically are entirely distinct. In *Hyrax* Krueg does not represent any indication of a Sylvian fissure whatever.

The supersylvian is very commonly called the suprasylvian. Leuret et Gratiolet have confused this fissure with the lateral in *Phoca*.

Following Krueg the fissure which is designated as the postsupersylvian, is commonly known as the postsylvian of Owen. What I have designated as the presupersylvian and which is only exceptionally independent, is usually described as the anterior or frontal portion of the supersylvian.

A fissure corresponding to the coronal is represented by Krueg as the presylvian in *Phoca*. Kükenthal makes a similar representation. Turner in *Macrorhinus* represents a corresponding fissure as the presylvian and a branch connecting with it

as the coronal. In *Trichecus* (walrus) he figures as the presylvian an apparent continuation of the lateral, and represents as the coronal an apparent continuation of a third arched fissure designated by him as the medilateral.

The superorbital fissure in carnivora generally is designated as the presylvian by many writers.

The cruciate fissure is shown by Krueg, in *Phoca*, as existing only on the mesal aspect, occuppying the position of the presplenial, or anterior sublimica of Kükenthal. Leuret et Gratiolet represent the fissure as seen on the ventral aspect at the cephalic end. Other writers place it as usually seen in carnivora at the cephalic end of the dorsal aspect where it may or may not reach the mesal surface.

THE LATERAL VENTRICLE (PARACOELE.)

On removing the dorsal portion of the hemicerebrum just dorsal to the callosum the lateral ventricle is revealed. In the bear the cavity bends cephalo-ventrad to form the precornu and caudo-latero-ventrad to form the medicornu. The striatum is a well defined body forming a portion of the floor of the ventricle in the cephalic region. Parallel with the oblique margin of the striatum is the fimbrial margin of the hippocamp. Between these two margins—the rima (great transverse fissure) the choroid (para) plexus—a continuation of the velum enters the floor of the cavity. The hippocamp pursues its usual curved direction in the medicornu.

In *Phoca* the lateral ventricle is relatively very much larger than in the bear and the parts present quite different relations to each other. The striatum is the same as in the bear; along its margin is a well developed plexus, but between this and the fimbrial edge of the hippocamp there is an area equally as large as the striatum; this is the optic thalamus, but that portion of of it represented in the floor of the cavity presents the same general appearance as to its surface (endymal) as do the other parts. The supposed delicate endymal membrane extending from the plexus to the fimbria has been designated as the paratela by Wilder. The hippocamp, then, is removed some little

distance from the striatum and arches around the surface of the thalamus in a ventral direction. Caudal to the hippocamp, the cavity is about as largely represented, and in size forms a disproportionately large postcornu. Along the mesal wall just caudal to the hippocamp is an ental ridge correlated with an ectal depression—the splenial fissure. This is comparable to the calcar or hippocampus minor of the anthropoid and human brains. It is larger in proportion than either of the above. The splenial in this case for a part of its course at least is, therefore, a total (Wilder) or complete (Cunningham) fissure since the whole thickness of the parietes is involved; the ental elevation being correlated with the fissural depression. In this specimen of *Phoca*, then, we have two total fissures, the hippocampal (always) and a portion of the splenial.

The conditions just described might naturally suggest a homology with the ape and human calcar and that the splenial fissure, in this seal possessing a postcornu, might be homologized with the occipital or calcarine fissure in man. A question might properly arise here as to which fissure it might be homologized with. In the human foetus the occipital is a total fissure, but loses its totality (ental elevation) in the adult. Its position might favor its homology with the splenial, for if the latter were rotated farther caudad it would come to occupy approximately the same position as the occipital. To homologize with the calcarine we would have to imagine a still farther rotation of the splenial. The calcarine is a total fissure throughout life and is the correlative of the calcar. Some doubt may therefore be expressed, assuming the homology to be reasonable, whether this hippocampus minor represents the occipital eminence—a foetal condition in the human brain, or the calcar—a structure persistent in the adult.

The relative disproportion in the growth of the caudal or occipital portion of the cerebrum may have some bearing in accounting for the presence of the postcornu. Tiedemann in his figure of the lateral ventricle of *Phoca* gives no indication whatever of a postcornu.

In *Callorhinus* the conditions resemble more closely those

in the bear; the rima is narrow and the thalamus does not appear at all in the floor of the ventricle. A slight caudal spur of the cavity at the medicornu represents the postcornu. The splenial fissure, so to speak, just escapes the cavity, lying immediately caudal to it.

In the walrus Turner[1] represents a dissection of this cavity but shows no indication of a postcornu, but in the text he states: "where the cavity of the ventricle curved downward and outward into the horn, an indication of a recess was seen in its posterior horn, but it did not amount to a cornu and there was no elevation which could be called a hippocampus minor."

Murie,[2] on the form and structure of the Manatee, figures a well developed postcornu. He states that, "there is an undoubted posterior cornu, a fully developed hippocampus minor and an eminence I am inclined to recognize as eminentia collateralis." The same author, On the Anatomy of the Sea Lion, *Otaria jubata*, figures a more extensive postcornu than is represented in the manatee and describes it as "stretching backwards and outwards with a very regular sweeping arch, and goes well back into the occipital lobe, terminating in a shallow tapering extremity. The eminentia collateralis is not distinctly defined; but what appears to represent the outwardly bulging hippocampus minor has a length of 0.7 of an inch, and at widest is 0.3 to 0.4 broad."

Wilder in the Anatomical Technology, in indicating the lines of inquiry likely to be most productive of results in the homology of the human and feline fissures, states that "between the ordinary carnivora and the monkeys are two groups whose brains should be studied with especial care; the seals have a rudimentary postcornu and occipital lobe, and these parts are said to be developed in the *Lemurs* which have affinities with both the carnivora and the primates."

In none of the accounts have I seen any direct mention of

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[1] '84. Turner, Report on the Seals collected during the Voyage of H. M. S. Challenger in the years 1873-1876.

[2] 1874. Transactions of the Zoological Society of London.

the correlation of the splenial fissure with the calcar in these aquatic forms. This fact, even if it be of no direct use for homology, is, at least, interesting.

MONACHUS TROPICALIS.

In August, 1897, I was fortunate to obtain through the courtesy of Dr. A. H. Hassall, Washington, D. C., two brains, from male and female specimens of the West Indian Seal *Monachus tropicalis*. They arrived at an exceedingly opportune time for comparison with the other brains dealt with in this article. A study of their form and fissural relations throw much light on some of the points which seemed quite aberrant in *Phoca* when compared with *Callorhinus* alone.

The general form of the brain would suggest a position intermediate between the fur seal and *Phoca* particularly in the frontal region which is somewhat foreshortened and broader than in *Callorhinus*. The caudal portion of the cerebrum is much elongated, noticed particularly upon the mesal aspect when measured from the splenium of the callosum; as if, perhaps, to compensate for the foreshortened frontal region. The cerebrum also shows a slightly greater overlapping of the cerebellum. The olfactory bulb and crus resemble the corresponding parts in *Phoca*, but show a slightly greater development.

Fissures. Postica. In all four hemicerebrums, this fissure sends a branch to the surface, thus appearing superficially as a branch of the Sylvian. The postica is less easily distinguished in *Monachus* than in any of the other forms, as it is submerged practically to the bottom of the Sylvian fissure. In *Callorhinus* there is a branch corresponding to that of *Monachus* but it does not extend deeply enough to connect with the postica.

The postrhinal appears as the merest trace of a fissure and has a very superficial connection with the postica.

The Sylvian fissure. It is in the Sylvian region that we get numerous clues to the intermediate position of *Monachus*. In the brain of the female the Sylvian has practically the same direction as in *Callorhinus*. In the male, the true Sylvian really branches cephalad, although there is a superficial extension in

the usual dorso-caudal direction. Apparently some unusual conditions exist here, which may perhaps be accounted for by the nearly complete disappearance of the postica.

The presupersylvian resembles the corresponding fissure in *Phoca* regarding its extreme vertical position and apparent union with the Sylvian for only the ventral third of its course. It differs from *Phoca* in not being disconnected from the supersylvian.

The supersylvian fissure resembles that of *Phoca* in extending a branch of good size to connect with the ansate.

Postsupersylvian. In the two hemicerebrums of the male there was a connection between the supersylvian and the postsupersylvian much as in *Phoca*. In the hemicerebrums of the female there was an entire disconnection of these fissures.

The cruciate fissure more than in any of the others resembled that of *Phoca*. It forms a good intermediate stage between *Callorhinus* and *Phoca*. As with *Phoca* the fissure is represented on the mesal surface as much, if not more than upon the dorsal. In the left hemicerebrums of both brains the cruciate is apparently continuous with the splenial. Upon the right hemicerebrums there is no such connection.

Precruciate. In all four hemicerebrums the precruciate extends over upon the mesal surface for some little distance. It is more largely represented upon the dorsal surface and its lateral end makes a very decided curve toward the coronal fissure. There is almost a superficial connection between the cruciate and the precruciate. The conditions in *Phoca* indicate that such a connection has occurred even to the extent of their almost complete mergence into eachother.

"Ursine Lozenge." This area is, with the exception of *Phoca* where it is undistinguishable, smaller than in any other forms. It is nothing more than a narrow gyre, situated at a slightly lower level than the adjacent gyres, suggesting a probable preparation for the loss of its identity in *Phoca*.

Postcruciate. In *Monachus* this fissure was the least satisfactorily represented than in any of the other forms. In the two hemicerebrums, it does not seem to be represented at all,

unless we interpret a slight branch from the cruciate as representing it. In the right hemicerebrums the fissure is distinctly present but is very small.

The splenial accords more closely with *Phoca* in its position, reaching the mid-dorsal region instead of extending farther cephalad as in *Callorhinus*. It sends off a branch corresponding to the postsplenial as in other brains.

The presplenial is well represented in the two right hemicerebrums, but in the two left it appears to connect the true splenial with the cruciate. The interlocking of submerged buttresses at the proper points indicates a superficial connection merely.

The marginal fissure is more poorly developed than in any of the other forms except the bear. A series of short interrupted fissures takes its place.

A well marked collateral fissure is present and resembles the corresponding fissure in *Callorhinus* very closely.

Postcornu. Perhaps the most important point in connecting *Monachus* with *Phoca*, is a very well developed postcornu. Callorhinus shows the merest trace of one and in the bear it is absent. In Monachus it does not go so far as in Phoca, a great portion of the caudal wall being solid. The floor of the postcornu in *Monachus* is quite distinctly convex This convexity of the internal surface is found to be correlated with an external depression, the lower or ventral portion of the splenial fissure. At the more vertical portion of the fissure, namely, opposite the caudal end of the callosum, the splenial fissure loses its totality and and becomes an ordinary fissure for the remainder of its upward course. The postcornu stops at the level of the depth of the splenial fissure in the callosal region. We have not, therefore, as in *Phoca*, a well developed calcar (hippocamus minor). The internal convex surface already spoken of in connection with the ventral portion of the splenial fissure, offers a suggestion as to the inception of the calcar which finds its fulfillment in *Phoca*.

GENERAL CONSIDERATIONS.

The average canine brain, as a matter of convenience, may be accepted as a simple type of a carnivore brain. The fissures are clearly demarcated and there is an absence of much branching or secondary fissuration.

Around the Sylvian there are three arched fissures separating the cortical substance into four distinct folds or gyres. In the brains of cats and occasionally in dogs we find that the arched fissure nearest the Sylvian is not a complete one; that only the pillars are represented, the keystone being absent.

In *Hyena* and *Proteles* the frontal portion of this arch is wanting (Krueg) but the caudal portion, fissura postica, is well represented. Correlative with this state of affairs the postsupersylvian, as compared with the presupersylvian, is situated at least twice as far from the Sylvian fissure.

In certain others of the carnivora no trace of the first arch or Sylvian gyre with its its limiting fissure (anterior-postica) is at all present. The first arch with its fissure has disappeared, apparently swallowed up by the Sylvian. There are represented then on the lateral aspect only two arched fissures, the supersylvian and on the lateral aspect only the three gyres which they separate. In those forms in which only the two arched fissures are present, if the distance from the frontal portion of the supersylvian to the Sylvian be compared with the distance from the latter to the postsupersylvian, it will generally be found to be less in the former, and this becomes much more emphasized in the case of some of the bears, where the frontal portion of an undoubted supersylvian almost enters the Sylvian fissure.

In his desciption of the brain of the Polar bear, *Ursus maritimus*, Turner says: "On opening up the Sylvian fissure I found to my surprise that a definite arched convolution was completely concealed within it. It was separated from the convolution which bounded the Sylvian fissure by a deep fissure which was also concealed. Its anterior limb, not quite so bulky as the posterior, was continued into the supraorbital area immediately external to the rhinal fissure and to the outer root of the olfac-

tory peduncle. Its posterior limb reached the postrhinal fissure and the *lobus hippocampi.* I could not but think that we had here, more completely than either in the walrus or seals, a sinking into the Sylvian fissure of the convolution which ought to have bounded it, so that both the Sylvian convolution properly so called, and the suprasylvian fissure were concealed within it. If this be a proper explanation of the arrangement, then the three convolutions on the cranial aspect would be saggital, mediolateral, and suprasylvian ; whilst the two complete curved fissures between them would be the mediolateral and lateral."

The question quite naturally arises if the fissure concealed in the Sylvian may not be the equivalent of the anterior-postica of Krueg and the two remaining visible on the cranial surface, the supersylvian and lateral.

The medilateral of other authors does not attain the size nor continued length in the frontal direction as ascribed to the mediolateral by Turner. And furthermore there is in some forms, as in the seals, a well defined medilateral in addition to the two principal fissures.

In a specimen of *Ursus americanus,* I had the good fortune to discover a stage one step beyond that described by Professor Turner. On opening the Sylvian fissure I found in its caudal wall a completely submerged fissure, with a remnant of the Sylvian gyre which might possibly be mistaken for the insula. A true insula, although small, is present. This submerged fissure I take to be the disappearing vestige of the ectosylvian (Owen) or anterior-postica (Krueg). A study of foetal bear brains with reference to the distinct appearance of the first circumsylvian arch (anterior-postica) would be most important in this condition.

It would seem then that the condition thus described in the polar bear and American bear would represent the method of disappearance, rather than the appearance, of the first circumsylvian arch and prepare us for the conditions that we find in the sea lion (Zalophus) and the seals (*Phoca* and *Callorhinus*).

In the sea lion the conditions regarding the frontal portion of the Sylvian gyre are intermediate between the bears and seals. The presupersyluian fissure approaches very closely to

the Sylvian fissure and the intervening portion of the Sylvian gyre, besides being narrower than in the bear, has also sunk slighly lower than the adjacent surface as if prophesying the conditions found in the seals.

In the seals there appears to be some evidence, if the interpretation as to the frontal portion of the supersylvian fissure be correct, that after breaking up into branches with perhaps some disconnection of its parts, it shows a tendency to follow the example of the anterior-postica fissure, because in *Phoca*, at least, the supersylvian bifurcates a little beyond the free end of the Sylvian, one branch forming a well defined arch around it, the other branch passing on in the frontal region. The branch, however, which forms the arch is not a long one but it extends to and superficially connects with a vertical fissure which for half its distance is submerged in the frontal wall of the Sylvian, and crops out again on the ventral aspect of the brain. This condition holds for both hemicerebrums of *Phoca*. *Callorhinus* throws a little light on this matter. In the right hemicerebrum the supersylvian is clearly continuous with the vertical fissure submerged in the frontal wall of the Sylvian but gives off a very short frontal branch. Superficially it is continuous with the postsupersylvian but a shallow at this point indicates a partial separation. The direct continuity in the depth of the supersylvian with the vertical fissure would seem to point to the fact that the latter, after all, was nothing more than the frontal portion of the supersylvian, namely the presupersylvian.

In the left hemicerebrum the parts are a little more complicated. The postsupersylvian is entirely separated, the supersylvian is entirely distinct from the frontal portion and is quite irregular and branching in its course, but mainly vertical in its direction.

Thus, taking the canine brain as exemplifying a simple fissural pattern and passing through the *Felidae* and *Ursidae* and sea lion to the seals where the fissures are more numerous and complicated by the presence of branches of considerable size, and more or less disconnection of some of the principal fissures, we may arrive at some understanding of the relationship and

changes effected in passing from simple to complex conditions.

In the general form of the brains that of the sea lion seemed to bear closer resemblance to that of the bear than either *Callorhinus* or *Phoca*—the latter the least of all. The elongated and narrow frontal portion of the brain as seen in the bear is represented in *Phoca* by a foreshortened and broadened region, less marked in *Callorhinus* and still less in *Zalophus*.

The development of the olfactory lobes is also interesting. They attain their highest growth in the bear, next in *Zalophus*, then *Callorhinus* and least in *Phoca*.

The triangular area on each hemicerebrum located between the cruciate and precruciate fissures and the intercerebral cleft, designated by Mivart as the ursine lozenge and believed by him to be of considerable importance in indicating a phylogentic relationship between the Pinnipedia and the ursine group of carnivora, was developed equally well in *Zalophus* and *Callorhinus*. In *Phoca* it was not observable, althougn Turner states that in this form it is present but rudimentary and concealed in the mesal fissure of the cerebrum.

The length of the lateral fissure in *Callorhinus* is somewhat unexpected and in relation resembles a continuous lateral and ectolateral of the bear. In the sea lion and *Phoca* the lateral is a relatively short fissure. In all but the bear there is an independent ectolateral fissure but it is not so satisfactorily developed in *Phoca*.

The postrhinal fissure shows an interesting variation in the different forms. In *Callorhinus* and *Zalophus* it has no connection with the rhinal or Sylvian, but it is a direct continuation of the subfissure—postica. In *Ursus* the subfissure may occasionally reach it but as a rule it is distinct and the postrhinal continues as an elongation of the rhinal. In *Phoca* the separation of the subfissure and the postrhinal is still more marked, so that the rhinal and the postrhinal are practically different parts of one and the same fissure, differentiated from each other by the presence of the Sylvian.

The presupersylvian fissure is directly continuous with the supersylvian in *Ursus*, it is likewise continuous in *Zalophus* and

in *Callorhinus* except upon the left hemicerebrum of the pup. In *Phoca* the two fissures are distinctly separated

The postsupersylvian is continuous with the supersylvian in *Ursus* and *Zalophus* but separated in *Callorhinus*. They are apparently continuous in Phoca, but a dorso-caudal branch and the presence of submerged buttresses at this point of junction would indicate that there was some attempt at separation.

In the bear there is no elongation of the paracoele to form a postcornu; in the sea lion Murie finds a distinct postcornu present; in *Callorhinus* it is quite rudimentary; in *Phoca* Tiedemann represents the paracoele with no appearance whatever of a postcornu. My own specimen, which so far as I know is normal, shows a postcornu relatively as large or larger than in the primate brain with a distinct calcar or hippocampus minor in which a portion of the splenial appears as a total fissure.

With the exception of the bear, concerning which I have no 'data, and the additional brain from an adult *Callorhinus* and *Monachus* all of my material was from specimens not more than one year of age. It is believed, judging from a comparison of the brain of the young with that of the adult *Callorhinus* as to bulk and complexity of fissuration, that comparatively little or no change occurs, especially in the latter respect.

Mr. Lucas, who had casts of the cranial cavities prepared from the male and female fur seal, finds but slight difference in the size of the cavities, notwithstanding the fact that the bulk of the body of the male is about four times as great as that of the female. Of the representatives of the five groups examined, the brain of *Callorhinus* shows a greater number of minor fissures and a more intricate arrangement and branching of larger fissures. With regard to the ground plan of the fundamental fissures, and allowing for the difference in the shape of the brains, that of the eared seals, *Callorhinus* and *Zalophus*, approximates in general more closely to that of the ursine carnivora than does *Phoca*. The latter, or earless seal, in some respects, appears aberrant. The arrangement of the cruciate and postrhinal fissures would seem to link it with the canine and feline carnivora; while the peculiar development of the occipital region and the large development of the postcornu with its calcar point toward primate conditions. The group of lemurs is also said to possess a postcornu and to have affinities with both the carnivora and the primates. As a matter of convenience a table of the more interesting regions in the representatives of the different groups examined is herewith appended.

	Region.	*Ursus.*	*Zalophus.*	*Callorhinus.*	*Monachus.*	*Phoca.*
1	Subfissure postica (?)	present	present	present	not very distinct	present
2	Postrhinal	Continuation of rhinal, exceptionally postica	Continuation of postica	Continuation of postica	A mere trace, very superficial connection with postica	Continuation of rhinal
3	Presupersylvian	Continuous with supersylvian	Continuous with supersylvian	On left hemicerebrum of pup disconnected but usually continuous	Connected with supersylvian	Disconnected
4	Postsupersylvian	Continuous with supersylvian	Continuous	Disconnected	In four hemicerebrums two show a connection and the other two a disconnection	Continuous but some indication of a shallow
5	Precruciate	mostly dorsal	Dorsal	Dorsal	Mesal and dorsal	Not clearly shown
6	Cruciate	Dorsal just cutting mesal margin	Dorsal	Dorsal	Dorsal and mesal	Dorsal and mesal
7	Postcruciate	Present	Present	Present	Rudimentary	Present
8	Minor fissures	Rare	not many	numerous	quite numerous	quite numerous
9	"Ursine Lozenge"	present	present	present	small	absent
10	Postcornu	absent	small	small	large	very large
11	Calcar	absent	absent	absent	Indistinct	very distinct
12	Medilateral fissure	present	present	present	present	a series of small disconnected fissures
13	Marginal fissure	absent	present	present	a series of short interrupted fissures	present
14	Collateral fissure	absent	rudimentary	present	present	present but connected with postrhinal
15	Insula	slight	slight	slight	slight	slight

DESCRIPTION OF PLATES.

REFERENCE LETTERS.

ans.—ansate fissure.
b.—buttress.
cal.—callosum.
calc.—calcar.
cf.—confinis fissure.
cl.—callosal fissure.
col.—collateral fissure.
cor.—coronal fissure.
cr.—cruciate fissure.
el.—ectolateral fissure.
f.—fimbria.
g.—genual fissure.
hip.—hippocampus.
l.—lateral fissure.
marg.—marginal fissure.
mc.—medicornu.
ml.—medilateral fissure.
pc.—postcornu.
pcr.—postcruciate fissure.
pl.—plexus.
prc.—precornu.
prcr.—precruciate fissure.
prh.—postrhinal fissure.
prsp.—presplenial fissure.
prss.—presupersylvian fissure.
psp.—postsplenial fissure.
pss.—postsupersylvian fissure.
r.—rostral fissure.
rh.—rhinal fissure.
so.—superorbital fissure.
sp.—splenial fissure.
str.—striatum.
Syl.—Sylvian fissure.
ss.—supersylvian fissure.
th.—thalamus.
ur.—ursine lozenge.

PLATE X.

Fig. 1. The ventral aspect of the brain of the fur seal *Callorhinus ursinus*. On each side of the cerebellum is a depression into which fits the petrosal portion of the temporal bone.

Fig. 2. The dorsal aspect of the brain showing the cerebellum largely concealed by the cerebrum.

Fig. 3. The left lateral aspect of the cerebrum of a young specimen.

Fig. 4. The right lateral aspect of the cerebrum of an adult male *Callorhinus*.

Fig. 5. The mesal aspect of the right hemicerebrum.

Fig. 6. The mesal aspect of the left hemicerebrum.

PLATE XI.

Fig. 1. The ventral aspect of the brain of the haired seal, *Phoca vitulina*, slightly modified from Tiedemann's figure.

Fig. 2. The dorsal aspect of the cerebrum of *Phoca vitulina*, after Tiedemann.

Fig. 3. The left lateral aspect of the cerebrum.

Fig. 4. The right lateral aspect of the cerebrum.

Fig. 5. The mesal aspect of the right hemicerebrum.

Fig. 6. The mesal aspect of the left hemicerebrum.

PLATE XII.

Fig. 1. The left lateral aspect of the cerebrum of the sea lion, *Zalophus californianus.*

Fig. 2. The right lateral aspect of the cerebrum of *Zalophus.*

Fig. 3. The mesal aspect of the right hemicerebrum.

Fig. 4. The mesal aspect of the left hemicerebrum.

Fig. 5. The left lateral aspect of the cerebrum of *Ursus thibetianus.*

Fig. 6. The mesal aspect of the right hemicerebrum of *Ursus.*

Fig. 7. Dissection of the left hemicerebrum of *Callorhinus,* showing the lateral ventricle with a very rudimentary postcornu.

Fig. 8. Dissection of the left hemicerebrum of *Phoca vitulina,* showing the presence of the calcar and large postcornu in the lateral ventricle.

Fig. 9. Dissection of the right hemicerebrum of *Monachus tropicalis* showing a postcornu of intermediate size.

PLATE XIII.

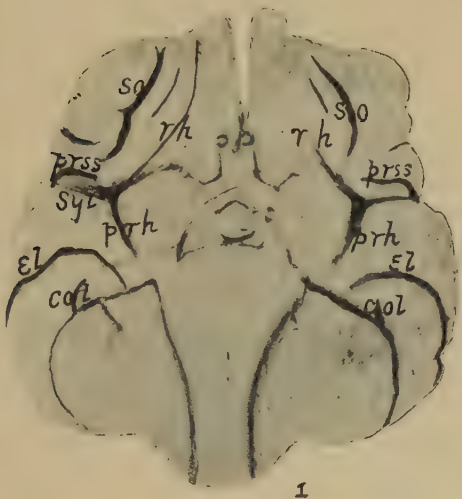
Fig. 1. The ventral aspect of the brain of a female *Monachus tropicalis.*

Fig. 2. The dorsal aspect of the brain of a female *Monachus.*

Fig. 3. The left lateral aspect of the brain of a male *Monachus.*

Fig. 4. The right lateral aspect of the brain of a female *Monachus.*

Fig. 5. The mesal aspect of the left half of the brain of a female *Monachus.*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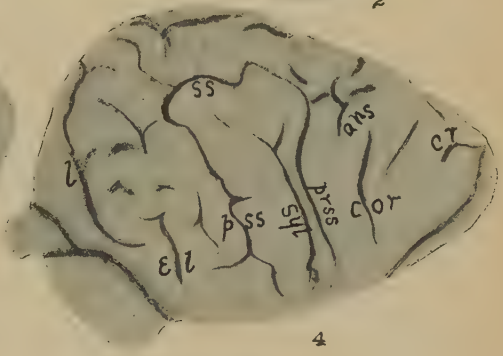
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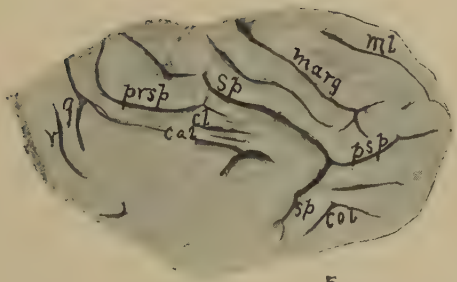
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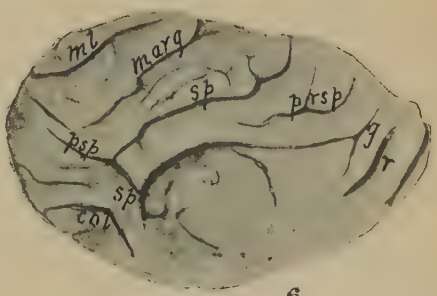
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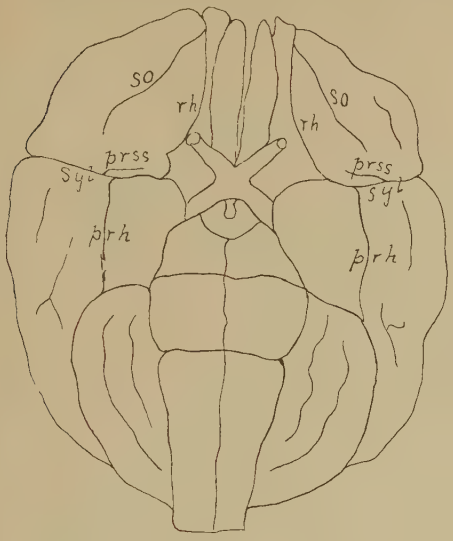

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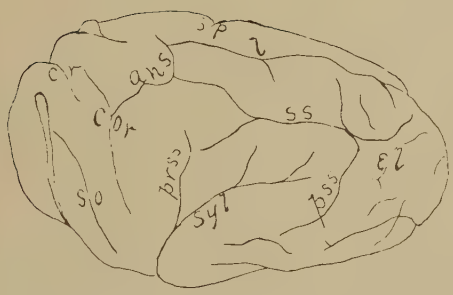

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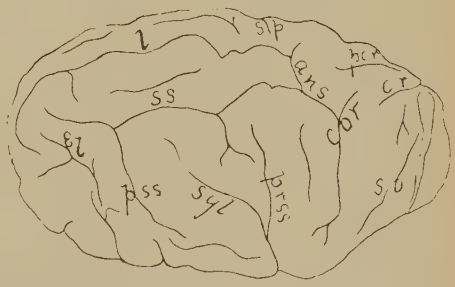

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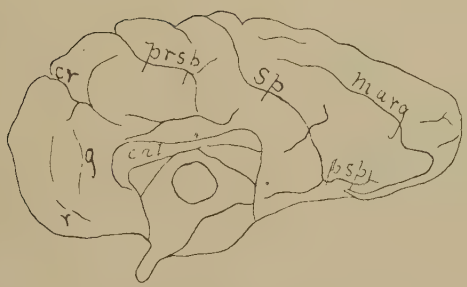

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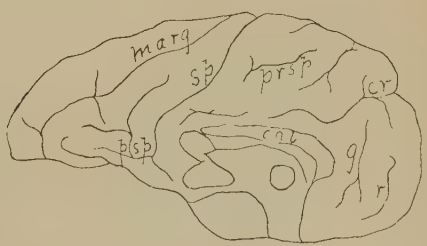

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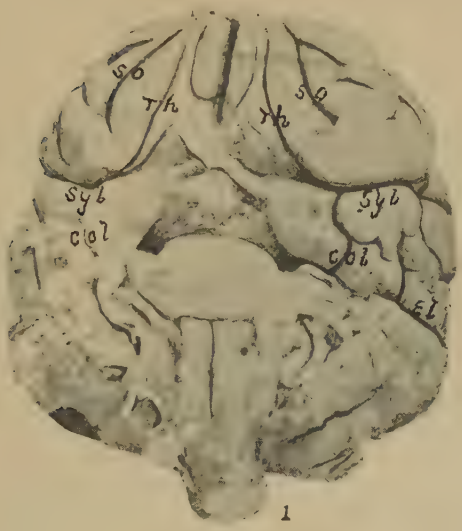
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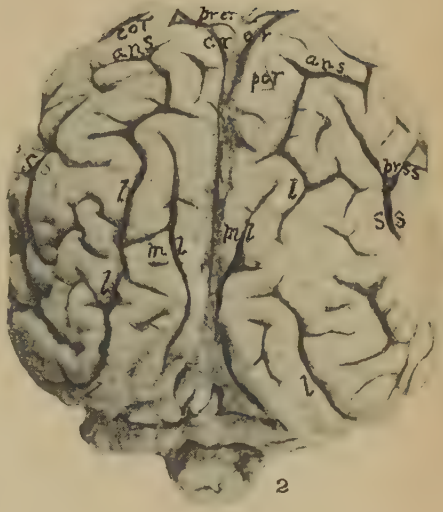
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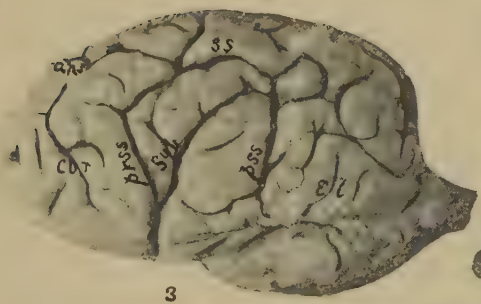
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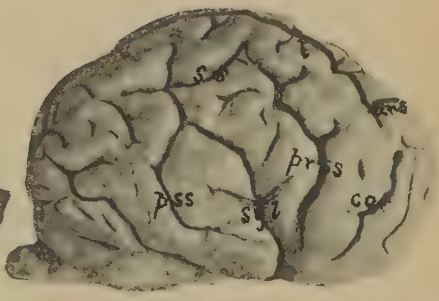
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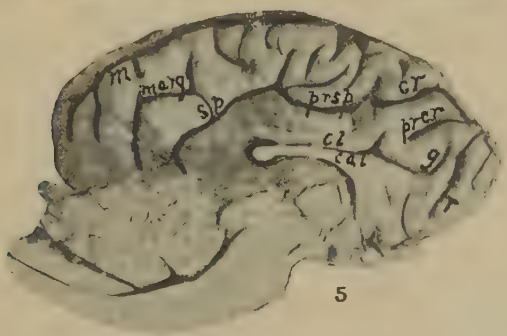
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THE NERVE CELL AS A UNIT.[1]

By Pierre A. Fish, D.Sc., D.V.S.,
Ithaca, New York.

With 7 Text-figures.

The sciences of morphology and physiology, perhaps more than any others, were of slow development. Their early years were enshrouded in mysticism and magic. Progress was retarded largely by theological opposition associated with superstition. The ancients believed that the soul was slow in leaving the body and that the latter should not, therefore, be used for dissection at once. The period allotted for this migration of the soul, left the body in anything but a fit state for investigation. This opposition did not extend to chemistry and other sciences, which, at that time, were in a flourishing condition.

With the *renaissance* there came a renewed interest in anatomy, and in Italy it was decreed that *one* body should be dissected annually at the universities. This, curiously enough, was done by a barber's assistant with a razor.

There was a time when it was the custom to administer to the inner, as well as to the outer, ills of mankind. Barbers were particularly adept at bleeding, and combined the science of phlebotomy with that of shaving. To advertise this profession they erected signs in the form of poles wrapped around with red and white bandages—the red to indicate the bleeding, and the white, the soapy lather. We must, doubtless, look upon our modern barber poles as heirlooms of this ancient and honorable profession, deprived, to some extent, of their old time significance.

Because the sphere was accepted as the symbol of perfection by the ancients, Plato regarded the more or less globular

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[1] Read at the quarterly meeting of the Cayuga County Medical Society, Auburn, N. Y., Feb. 10, 1898.

head as the seat of intelligence and perception. With slow gradations the apparent fantastic and irregular form of the wrinkled brain surface has been systematized into a general ground-plan. Segments have been differentiated and a fissural pattern for the cerebrum has been formulated. Deeper than the surface, however, there is encountered a bewildering maze of cells and fibers, the intricate arrangement and complex relations of which have at the present time, only begun to be understood.

In the achievement of a great discovery, many are prone to overlook the factors by means of which it is made possible. The discovery of a new planet very justly brings great renown to the discoverer,—we usually stop at that and take no cognizance of the wonderful mechanism of the telescope, the laws of astronmy, and other accessories that co-operate in the grand result. And so it has been with our knowledge of the structure of the nervous system, great as it is today but at the same time inadequate. The results of the last ten years which have so completely revolutionized our conceptions of the nerve elements were possible only through improvements in microscopical apparatus and technique, and the improvement of histological methods. With the additional knowledge gained from the new methods, there must of necessity occur change in the terminology. The old notion of a nerve cell (justified by the old methods) that it consisted merely of a cell body with its enclosed nucleus and nucleolus is no longer tenable. Important as are these parts to the nutrition and activity of the cell, no less important to the full attainment of its function is the presence of its various appendages.

The Golgi-Cajal method is too well known to require any description. The formation of a silver-bichromate deposit in or upon the nerve cell and its processes has furnished us with pictures of these elements, which for beauty and clearness of outline surpass anything that has preceded it. The results furnish us with at least a workable hypothesis regarding nervous phenomena which before was merely conjecture.

This method has shown, and accumulated evidence seems

to confirm it, that there is complete morphological independence of the nerve elements, with perhaps certain exceptions, in rare cases, where a direct anastomosis of one nerve cell with another has been described, as in the battery of the torpedo and also in certain of the sense organs, as noted by Dogiel, Ayers, Masius and others. This morphological isolation of the elements does not preclude the idea of physiological continuity which must of necessity exist.

This isolation of elements has led to the production of the term neuron (Waldyer '91), neurone (Van Gehuchten '93), neurocyte (Fish '94, after an unknown French writer), neura (Rauber '94) and neure (Baker '96), to signify the nerve unit, including the cell body with all its appendages. The term neurocyte has been suggested in this connection because its literal meaning is a nerve cell and includes not merely the cell body, which from custom we regard as the equivalent of a nerve cell, but all of its appendages as well, just as in speaking of the leucocyte, we include the various extensions from the cell mass. The analogy may be carried still farther for under certain special conditions we may conceive that the pseudopodia of the leucocyte may be considerably extended and attenuated and from the juxtaposition of numerous other elements lose, or partially lose, their powers of retraction and movement; under such conditions we may consider the neurocyte comparable with the leucocyte so far as form is concerned.

The appendages of the cells, with perhaps the exception of those of the spinal ganglia, appear to fall naturally into two categories; those which collect or convey the impulse to the cell, cellipetal processes or dendrites, and those which discharge or carry impulses away from the cell, the cellifugal processes or neurites (axis-cylinders).

Along with our increasing knowledge of the form of neurocytes there have been contributed new facts bearing upon their activity. For our purpose, we may consider the neurocyte as made up of a mass of granular protoplasm, with more or less branching appendages, containing a large nucleus of a reticulated character enclosing, usually, a prominent nucleolus. We

have a bit of material protoplasm similar to that of other body cells, and yet for a long time any structural change due to the activity of the nerve cell eluded the keen vision of investigators. It has been said that the secretion of a gland cell is of a material character; that of a muscle cell, mechanical energy and we might naturally expect to find in these tissues, changes demonstrable by the microscope; but the secretion of a nerve cell is consciousness which is not exactly material, and its effect upon the cell is too subtle to leave a trace. Hodge [1] in his fatigue experiments extending over a period of four or five years, has shown the fallacy of this view. His experiments dealing with artificial and normal fatigue were performed in a most faithful and conscientious manner on a wide range of forms with conclusive results, the most of them having been confirmed by later investigators.

Fig. 1.

Fig. 2.

Fig. 3.

Figs. 1, 2 and 3, after Hodge. Only the cell bodies are shown. Fig. 1, represents the normal cell body with its large reticulated nucleus and the chromatin diffused throughout the cytoplasm. Fig. 2, shows the effects of fatigue, the nucleus having become shrunken and irregular in outline, with a surrounding area devoid of chromatin. The peripheral portion of the cytoplasm is also poor in chromatin. Fig. 3, showing vacuolation of the cytoplasm as the effect of fatigue.

For the artificial fatigue experiments the spinal ganglion cells were chosen and the nerve connecting with the ganglion was subjected to a weak electrical stimulation for a given length of time. The spinal ganglion of the opposite side was removed *without* stimulation and used as a control in the experiment, the treatment of the two ganglia being identical after they were removed from the body. In the fatigued cells he found slight shrinkage in size, with vacuolation of the protoplasm. In the nucleus there was a marked decrease in size, nearly 50%; a change from a smooth and round to a jagged, irregular out-

[1] Jour. Morphology. Vol. VII. Pages 95—164. 1892.

line; and a loss or condensation of the open reticulated appearance. The control ganglion showed none of these changes. If, after stimulation, the cells were permitted to rest and then examined, these changes were not apparent. For the study of normal fatigue, certain birds and bees were examined, some of them were killed before entering their daily routine, while their cells were presumably as yet in a state of rest; others were killed just at night-fall after the completion of their day's work. A comparison of those killed in the morning with those killed in the evening, showed in the latter changes as marked as those produced by artificial fatigue. To make the evidence still stronger, and to show that the effects were not the result of histological reagents, it remained for Dr. Hodge to study the living cell. For this purpose he chose the cells of the sympathetic ganglia of the frog. Two frogs were prepared in exactly the same way, except that one received a weak electrical stimulation while the other did not. The unstimulated frog showed no change, while the nucleus of the cells of the stimulated frog showed very marked shrinkage and irregularity of outline. Certain well defined changes in the constitution of the nerve cells of very old persons as compared with the newly born have also been demonstrated. Hodge has shown that fatigue effects occur in brain cells as well as those of the spinal ganglia.

As early as 1884, Flesch noted differences in cells in their reaction to staining reagents due to internal modifications as an effect of their functional activity, and according to this affinity for color he designated the cells as chromophile and chromophobe.

Vas ('92) has demonstrated changes in the cells of the cervical ganglia, due to their functional activity, and confirms, in the main, the points that have just been stated. As a preliminary result of this activity Vas has further noted that there is, at first, a swelling of the cell. This has also been confirmed by Mann ('94) who has extended the observations to the motor cells of the spinal cord and the sensory cells of the retina of the dog. From his researches, Mann concludes that during rest,

several chromatic materials are stored up in the nerve cell and that these materials are used up by it during the performance of its function; that activity is accompanied by an increase in the size of the cells, the nuclei and the nucleoli of the sympathetic, ordinary motor and sensory ganglion cells; that fatigue of the nerve cell is accompanied by the shriveling of the nucleus and probably also of the cell and by the formation of a diffuse chromatic material in the nucleus. Lugaro ('95) confirms the observations of Mann.

Cellular changes of such a radical character, as has been shown above, may be the result of perfectly normal functions and disappear after a period of rest. How important is it, then, before discriminating between that which may be perfectly normal and that which is abnormal, to know thoroughly the effects incident to natural activity.

In connection with the matter of electrical excitation of the nervous system, the question naturally arises, since we have such complete evidence from an experimental standpoint, what will be the result of the application of a fatal current of electricity? Will a very strong current applied for a few minutes affect the structural character of the nerve cells in a manner similar to those stimulated by a weak current for a very long time? As opportunities have presented there have come to me portions of the brain and myel of four persons executed by electricity, as well as from a horse struck dead by a live wire. In the first case, designated as W, a portion of the oblongata, the location of so many vital centers, was carefully studied. The number and size of the vacuoles in the cytoplasm were astonishing. In all, however, the nucleus appeared full and regular, although the cytoplasm in some of the cells seems to have become completely transformed into vacuoles.

In the second case, L, examination was made of the same region and here no abnormal change of any kind could be detected. The cells were full and plump as were also the nuclei and the nucleoli, and the cytoplasmic chromatin showed no evidence of disintegration or disappearance. A portion of the cortex was also examined and in both the large and the small

pyramidal cells a very considerable amount of vacuolation appeared, especially in the apical dendrites, and occasionally in the body of the cell.

In the third case, B, only a small portion of the cerebellum was studied. It required considerable search and patience to find in these sections any distinct structural change of the cells. After the examination of many sections two Purkinje cells were found, each of which showed the presence of a small vacuole.

The fourth case, C, required more than one current to cause his death. The pyramidal cells of the cortex were also examined and those of the oblongata to a lesser extent. Here also there was evidence of vacuolation in the apical dendrites of the pyramidal cells, while the others, including those of the oblongata, so far as examined, were perfectly normal.

In the case of the horse the injury was inflicted at the shoulder, differing thus from the others in point of contact with the electricity. No unusual appearances were detected in the neurocytes.

I have ventured to present these results, incomplete as they are. If they do nothing more, they will, I think, emphasize the importance of a working knowledge of the changes that may occur in a neurocyte as a result of its legitimate processes. The vacuolation of the cell body and of the nucleus is described by many to be due to pathological causes of various kinds, among which may be mentioned, insanity, alcoholism, epilepsy, as well as the action of various toxins and alkaloids. As has been shown by Hodge and others, many of the described pathological changes may be duplicated by normal processes, and these, so far as possible, should be eliminated before rendering a decided opinion.

Bearing upon the matter of the rapidity with which effects may be produced upon the nerve cells as a result of shock are recent experiments of Parascondolo ('98)[1] who produced upon guinea pigs a condition of shock by striking some of them upon

[1] Arch. de Physiol. norm. et path. XXX. 5th series. X. No. 1. p. 138.

the thorax and some upon the abdomen. If the animal died immediately there were no results detected in the nervous system If, however, the animal lived thirty or forty hours, as some of them did, well marked lesions were demonstrated. By Nissl's method he found in the motor cells of the myel a perinuclear, as well as a peripheral chromatolysis, also vacuoles in the cytoplasm and an eccentric position of the nucleus. By the Golgi method he found deformation of the cell body but not to the extent of atrophy, and a distinctly moniliform appearance of the dendrites.

An inference derivable from the above experiments, is that changes of a structural character do not occur instantaneously in the neurocyte, especially if the injury be not directly applied to the nervous system. Parascondolo's experiments are of interest in showing how soon the lesions may be *induced* through the inter-dependence of the tissue systems. A comparison between these experiments and the results of electrical excitation shows that fatal currents of electricity may *induce* changes in the dendrites of the nerve cells in a practically instantaneous period of time, under unfavorable conditions, as the current is prevented from direct action upon the brain by the presence of the meninges, bones of the cranium, and scalp. With the weaker

Fig. 4.

Fig. 4. After Cajal, showing the transformation of the bipolar into the unipolar spinal ganglion cell.

currents practically the nervous tissue alone was dealt with, under the most favorable conditions. Other things being equal, we may expect that a current of greater intensity will produce given results in less time than a current half as great. Pugnat[1] has demonstrated this in his experiments, finding that it required

[1] Bibliog. Anat. VI, pages 27-32, 1898.

twice as long to produce certain results with a weak current as when one of twice the strength was used.

We must avoid the danger of regarding the cerebro-spinal axis as a rigid and unyielding mass of substance. The action of the brain is molar as well as molecular, as evidenced by its general movements due to inspiration and expiration. In the earlier stages of development there are migratory movements of the neuroblasts of an amoeboid nature in order that they may reach their destined positions in the adult structure. The so-

Fig. 5.

Fig. 5. After Cajal, showing the changes undergone by the cerebellar granule cells, reading from left to right.

called bipolar spinal ganglion cells are the permanent condition in such low forms as the "fishes;" those of higher forms pass from this stage in early development to the unipolar condition of the adult.

Fig. 6.

Fig. 6. After Fish (Central Nervous System of *Desmognathus fusca*), showing the changes in the form of the neurocytes as they pass from the ental to the ectal boundary of the layer of nerve cells.

Cajal has shown that during their growth the granule cells of the cerebellum pass through even more elaborate changes than those of the spinal ganglia. Changes in the form of the cells and their appendages are also apparent in the central ner-

vous system of certain salamanders, as the neurocytes reach the boundary of the cellular layer.

Here are evidences of the plasticity of the nervous elements. Do they lose this property entirely after they have reached maturity? It has been pretty well demonstrated by modern histological methods that these elements are morphologically independent, and the hypothesis of *contiguity* or overlapping of the parts is now very generally accepted, instead of the older view of continuity or direct anastomosis of one cell

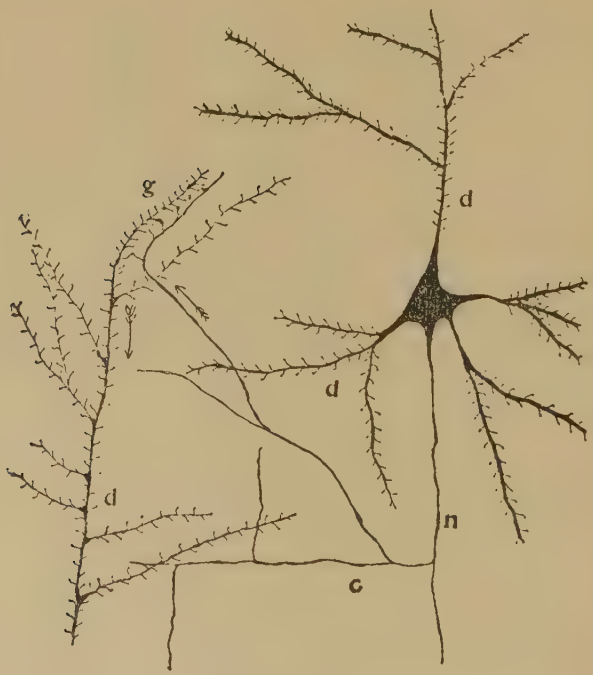

Fig. 7.

Fig. 7. After Berkley, showing a nerve cell with its processes (human); *n*, neurite ; *c*, collateral ; *d*, *d*, *d*, dendrites ; *g*, gemmulæ. Illustrating Berkley's hypothesis of the way in which the nervous impulse may pass from one nerve cell to another by contact of the gemmulæ.

with another. Contact of one element with another is sufficient, it is believed, for the transference of a nervous impulse. The

idea has been advanced that even in the adult state the neurocyte has not completely lost its power of amoeboid movement, but that this property is still retained at the terminals of its appendages. This view is not accepted by Kölliker, nor entirely by Cajal, who thinks that the neuroglia cells are more mobile than the nerve cells.

The experiments upon the activity and fatigue of the nerve cell indicate that a change of volume may occur, a turgescence as a result of activity, and a shrinkage when carried to the extent of fatigue. Situated in the lymph spaces and constantly bathed with the lymph for nutritive purposes, we may expect to find certain osmotic processes going on between the contents of the cell and its surrounding medium and that these processes may be influenced by the activity of the cell and that certain of them may occur coincidently with the transmission or origination of the impulse in the cell.

Along the dendrite, and especially well pronounced in the cortical cells, are slight lateral spurs known as gemmulæ. The condition of these, as well as certain irregularities in the form of the dendrites, have been noted by Berkley and others as the result of pathological causes. Berkley has shown that in certain diseased conditions gemmulæ have been missing. He believes that the cell and its dendrites has a delicate limiting membrane through which the gemmulæ protrude, as naked bits of protoplasm, coming into contact with similar uncovered masses of protoplasm from the neurite or its collaterals, or in contact with the gemmulæ of other dendrites and that at these points the impulses are transferred. Any destruction or abnormality of these gemmulæ would of course, interfere more or less seriously, with the normal conveyance of the impulse.

The transference of nervous impulses from one element to another through contact, due to amœboid movement, would be of material importance in the explanation of the phenomena of sleep, intellectual processes, and pathological conditions. Before pathology has spoken its final word we may hope to know more of the remarkable chemical complexity of nervous tissue, composed, as it is said, of some three hundred or more different ele-

ments and compounds. If, in closing, I could have one fact shine out beyond any other it would be the idea that, while there is a morphological independence of the nervous elements, there is a physiological dependence; that, although there is unity there is community; and that a healthy psychic life is the result of the summation of the individual activity of all the nervous elements.

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(*From the Proceedings of the Seventeenth Meeting of the Society for the Promotion of Agricultural Science, held at Buffalo, N. Y., August, 1896.*)

THE INFLUENCE OF ANIMAL EXPERIMENTATION UPON AGRICULTURE.

BY VERANUS A. MOORE.

The benefits to agriculture derived from investigations upon animals are to be largely measured by the successes which have been attained in the prevention, limitation of the spread, and the complete eradication of infectious animal diseases. Plagues in the form of these affections have from the earliest times been a source of constant dread, and all too frequently, the cause of extreme suffering among the people, due to the loss of innumerable animals which afforded them food, clothing and a means of transportation. Rinderpest, or the great cattle plague, in England, in 1865, is estimated to have caused a loss of between $40,000,000 and $50,000,000 worth of cattle. From 1839 to 1870

the total loss from the ravages in England of two cattle diseases is placed at $400,000,000. The various infectious and contagious diseases baffled all attempts at prevention or eradication. Their causes were not known and veterinarians and cattle raisers were equally in the dark as to remedies. During the two decades from 1870 to 1890, Pasteur and other investigators, proceeding by similar methods, demonstrated the specific nature of many of these diseases, i.e., they showed that they were due to the presence and multiplication in the body of microscopic organisms. These discoveries at once destroyed the mischievous theory of their spontaneous generation and led the way to the present successful methods for their prevention.

The question naturally arises, How was it possible to demonstrate that a certain agent or organism was the cause of a certain disease? This could only be done by feeding or inoculating healthy animals with the supposed specific organisms and observing the results. If the inoculated animals contracted the disease, while uninoculated ones, kept under like conditions, remained well, and if from the organs of these diseased animals organisms were obtained which possessed the same peculiarities of growth, and were capable of again producing the disease in healthy animals, their specific nature was placed beyond reasonable doubt. By this method, and by this alone, has it been possible to demonstrate the nature of the infectious diseases, and to bring them under the present high degree of subjection.

The few well recognized animal diseases for which a specific agent has not been demonstrated, have had their contagiousness or non-infectiousness determined by means of experiments upon animals.

The number of infectious diseases to which our farm animals are susceptible, and the losses which they have frequently produced, are usually overlooked in times of prosperity. In order to show the economic importance of these maladies, and to point out a few of the marvellous results which have been obtained from animal experimentation, and which have either directly or indirectly greatly benefitted the agricultural interests of this country, I wish to call your attention to the history and present status of the more important of these affections.

The Progress which has been Made in the Eradication of Infectious Animal Diseases.

Contagious pleuro-pneumonia.—This disease is said to have originated in the highlands of central Europe from whence it spread to every cattle raising country in the world. It was probably introduced into the United States in 1843, in a cow imported directly from Europe, and taken from shipboard into a Brooklyn cattle shed. At first its spread was not rapid, several years elapsing before it became widely disseminated in the Atlantic states. It was not, in fact, until about 1880 that it became evident, to those most familiar with the disease, that if it were not eradicated, it would, through some one of the increasing number of avenues of transportation, soon reach the great cattle ranges of the West, and ruin the cattle industry of this country.

The general dissemination of this disease was due to the ignorance of the people concerning its contagiousness. In 1851, experiments at Pomerage, France, demonstrated its infectious nature, and showed beyond doubt that it would spread from diseased to healthy animals. Owing to general skepticism, these results were not accepted until they had been many times repeated. This was particularly true in the United States. The American mind wanted additional evidence and the result was the well known experiments made Dr. D. E. Salmon[1] in 1884 on Barren Island. These furnished such undoubted evidence of the infectious nature of the disease, that it was not difficult to obtain from Congress the necessary legislation and appropriation for instituting methods believed to be suitable for its complete eradication. As a result, every trace of this disease was removed from the United States within the brief period of less than six years and at a cost ($1,509,100.72) that was trifling in comparison with the losses likely to occur annually as soon as the disease had obtained a foothold among the cattle on the western plains.

Infectious swine diseases.—The important infectious diseases of swine known to occur in the United States, are hog cholera and swine plague. The first recorded epizoötic of hog cholera occurred in Ohio in 1833. It gradually spread, until it became a menace to this branch of animal industry. In 1889, Dr. Salmon estimated from carefully compiled data that the losses in the United States

[1] First Annual Report Bureau of Animal Industry.

from this disease alone, amounted to from $10,000,000 to $25,000,000 annually. In other words, a disease supposed to have been introduced from Great Britian about 1830, had become a general and unquestioned plague by 1870. The nature of the disease remained unknown until 1885, when a motile bacillus was found to be its specific cause, and the following year the effect of various disinfectants on this organism was determined. In 1886 swine plague was differentiated from hog cholera, and its specific organism was discovered and described.

Protective inoculations have not, as yet, proven to be satisfactory with these diseases, and consequently further and different experiments should be made. However, the infectiousness of these maladies, and the various ways by which their organisms can be carried from place to place have been determined. Knowing, therefore, that these diseases are of a specific nature, and knowing under what conditions the specific agents can be carried, we are in possession of important preventive measures. The efficiency of this knowledge has been demonstrated in the infected localities by many farmers who have followed the prescribed methods for keeping the organisms of these diseases away from their hogs.

Tuberculosis.—In 1865 Villemin demonstrated by inoculation of healthy animals with tubercles, that tuberculosis was an infectious disease, and in 1882 Robert Koch, after repeated experiments upon animals, discovered and isolated its specific organism. But for these and similar experiments, we should still be totally in the dark as to the cause of this disease, and unaware of its communicability from animal to animal.

The importance of these discoveries is too great for ready comprehension. Tuberculosis, while not characterized as an epidemic or epizoötic disease, is estimated to be the cause of 14 per cent. of all the deaths in the human family, while of the post mortem examination of the cattle slaughtered in the abattoirs of ten foreign cities and countries, an average of nearly 18 per cent.[1] have been reported to be tuberculous. In the United States it is estimated that from 3 to 20 per cent. of the dairy animals have tuberculosis.

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[1] Statistics collected by Freeman, *Medical Record*, March, 28, 1896, p. 433. In detail they are: Berlin 4.57, Munich 2.44, Augsburg 2.24, Mulhausen 3.4, Hanover 60 to 70, France 5, Paris 6, Holland 20, Pomerania 50, Mexico 34 per cent.

Several herds have come to the writer's notice, in which from 75 to 90 per cent. of the animals were found to be diseased on post mortem examination. Not only is there a large amount of tuberculosis in our cattle, but it is rapidly spreading. A state veterinarian recently told me that the spread of this disease among cattle was appalling. Sanitarians have recognized the danger of human infection from the consumption of milk from tuberculous cows, and the discovery of tuberculosis in pigs fed upon such milk is a practical demonstration of the transmission of the virus through this medium. The cause of this disease, the manner of its dissemination, and the means (tuberculin test) by which it can be detected in its early stages, have been discovered, the remaining unsolved problem being the one relating to the best method for the elimination of the diseased animals. When this is solved, and the existing centers of infection removed, the enormous losses annually sustained by deaths from this disease ought practically all to be saved. Judging from the known facts, it is highly probable that if attention had not been called to this disease in cattle, and a sure method for its detection devised, it would have soon become a more universal and destructive plague than any which has yet visited the American Continent.[1]

Glanders.--This is one of the equine diseases which has been longest known. The ancient Greek and Roman authors describe it, and speak of the extensive losses it produced. Many theories existed concerning its source, the most prevalent one being its transmission in some unknown way through the air. Towards the end of the last century, Abildgaard and Viberg demonstrated by numerous animal experiments that it was transmissible by inoculation. In 1837, Rayer showed that it was communicable to man, and in 1882 its specific organism was described. It is hard for us to understand with what difficulty the contagiousness of this disease was established, notwithstanding the enormous losses it was annually causing. Skepticism died out, however, when Loeffler and Schultz were able to produce the disease with pure culture of the bacillus and were able to show how it could spread, through the nasal discharges, from infected to well horses. Another victory like

[1] A recent writer who has studied this subject very thoroughly, states that "This disease has caused more deaths in the human family the world over, than the accumulated loss of life from war, famine, plague, cholera, yellow fever, and small pox."

the tuberculin discovery was realized in the production of mallein from cultures of the glanders bacillus. By the use of this substance, the disease can be detected in suspicious cases with the same degree of certainty that tuberculosis is found in cattle. It thus affords an unquestioned arbitrator in all disputed cases. Glanders, like tuberculosis, is transmissible to man, and already a very large number of cases have been reported in men who have had the care of horses. While the present value of horses is much reduced over that of former times, it is no less a benefit to the agriculturist that his animals are protected against this disease. Since the introduction of the mallein test, and the enforcement of sanitary regulations compelling the destruction of condemned animals, the amount of glanders has been reduced to a great extent. While general statistics are wanting, the importance of this disease can be understood from the fact that in ten years (1876–1886) in Prussia alone, it destroyed 20,566 horses.

Anthrax or malignant pustule.—This is supposed to have been the "sixth plague of Egypt" mentioned by Moses. It was described by Homer, and Plutarch has given the history of an epizoötic of anthrax which existed in Rome about the year 740 B. C. Extensive outbreaks of this disease have occurred at short intervals since that time. It has become widely disseminated, existing on every continent of the globe. The amount of loss caused by this disease in former years was appalling. In Australia it is said to have destroyed 300,000 sheep annually. Formerly the annual loss in a single department of France amounted to $2,000,000. In 1884 it destroyed in another section 4,000 horses, 2,000 oxen and 1,000 small cattle. In Novgorod in 1867-8, its victims are said to have been 40,000 horses, 8,000 cows, 6,000 sheep and 500 human beings.

Passing from the enormous losses and fearful suffering formerly caused by this disease to the improved conditions of the present time, we find, as in previous instances, that the remedy was discovered by experiments upon animals. The simple discovery and demonstrations by animal inoculations of the bacillus of anthrax did much to lessen the amount of the disease. Knowing its specific nature, the dead animals could be disposed of in such a way as to prevent the spread of the virus, and greater care could be exercised in the interchange of animals and in the selection of pasture lands. In 1881 Pasteur demonstrated his

method of protective inoculation. Since that time the extent of its application and the benefit derived from it can be appreciated only after a study of the statistics which have been compiled from the reports from different countries in which it has been used.

In 1894 Chamberland reported that a total of 1,988,677 animals had been inoculated in France, and the loss from anthrax had diminished from 10 per cent. in sheep, and five per cent. in cattle to less than one per cent. in sheep and one-fourth per cent. in cattle, a saving of over $2,000,000.

In Spain this disease prevailed among the sheep, cattle, and horses, and the former mortality of livestock has been estimated as high as 20 per cent. Since the use of Pasteur's vaccine, the mortality is estimated at less than two per cent. In Austro-Hungary the former losses were very heavy, ranging from 10 to 60 per cent. of the cattle and sheep. They are now reported to be on an average of less than one per cent. Similar benefits have been realized in other parts of Europe, and laboratories for the preparation of the vaccine have been established in several of its countries. Like smallpox in the human subject, anthrax has lost much of its terror for the farmers of Europe.

In the United States, losses from this disease have not been so extensive, but the records show annually outbreaks of serious proportions. Our knowledge of the specific cause, however, has enabled the authorities to enforce regulations to prevent its spread. Without this knowledge it would undoubtedly soon be as prevalent and destructive to our farm animals as tuberculosis.

Rabies or hydrophobia.—Among the diseases of man, none are more dreaded and in animals few are more pitiful than rabies. There is no longer any disagreement among pathologists as to the existence of this disease, or as to its dangerous nature, it being readily communicated from rabid to healthy animals. In the maladies heretofore cited, with the exception of contagious pleuro-pneumonia, the specific organism has been found, isolated, and cultivated on artificial media. In rabies, the search for the specific agent has been less successful, but practically quite as fruitful. The facts have been established by experiments, that when rabbits are inoculated with a bit of the spinal cord or brain of a rabid dog or other animal, they will die after a certain length of time (usually from 15 to 30 days) with definite and characteristic symptoms, and that when rabbits are inoculated by the same

method with the spinal cord or brain of healthy dogs, they will remain well. In 1884, Pasteur made his brilliant demonstration of his method of conferring immunity against rabies or hydrophobia before a commission of scientific men appointed to make an investigation into its merits. Concerning his first inoculation in man, Pasteur wrote: "Making use of this method, I had already made 50 dogs of various races and ages immune to rabies, and had not met with a single failure, when, on the sixth day of July, quite unexpectedly three persons, residents of Alsace, presented themselves at my laboratory. One of these, a boy of nine years, who had been bitten in fourteen different places by a rabid dog, was saved." At Pasteur's Institute in Paris, 9,433 persons were treated during the years 1886 to 1890 inclusive. The total mortality among those treated was 0.61 of one per cent. In 1890, 416 persons bitten by dogs proved to be rabid, and among these there was not a single death. In 1891, the number of persons treated was 1,539, with a mortality of 0.25 of one per cent., and in 1893, 1,790 inoculations were made with a mortality of 0.22 of one per cent.

While the extensive investigations of Pasteur have resulted in giving us a specific for this disease in man, the farm animals are less fortunate on account of the attending expense and the usual ignorance on the part of the owners of their exposure. The writer had the honor of positively diagnosing rabies in a herd of cattle in the state of Iowa in 1892, in which eleven valuable animals died. The disease was looked upon as a "mysterious plague" and would still have been regarded as such if it had not been for the definite methods of diagnosis by means of animal inoculation. Several similar outbreaks have been reported. In the Atlantic states the losses of cattle and horses from rabies are quite considerable. In fact, there are many reasons for believing that cases of this disease are becoming more numerous. In the city of Washington, during a period of two years (Dec. 1892 to Dec. 1894) inoculations made in the Bureau of Animal Industry demonstrated the existence of 15 cases of rabies (one in a negro, one in a horse and thirteen in dogs). During the past year, the same methods have shown the existence of eight cases in the same city. One in an elderly lady who was bitten by her pet dog, two in foxes, and five in dogs. Although Pasteur's treatment has reduced the mortality in people bitten by mad dogs from an

average of 47 per cent. in 1875 to less than one per cent. in those who take it[1], the remedy is at present beyond the reach of many, and certainly our cattle and horses are excluded.

As a preventive measure there should be an extermination of thousands of useless dogs, especially those running about our cities and towns. The practical application of this great discovery by Pasteur, lies in determining by rabbit inoculations, whether the suspected dog was actually rabid and, if so, in checking the further spread of the disease by placing all animals that have been bitten in close confinement, and providing the Pasteur treatment for all of the human victims.

Texas or Southern cattle fever.—The investigations begun in 1889 by the Bureau of Animal Industry have shown that this is a disease of the blood due to the presence of a microparasite. Its history is most interesting. If cattle from the permanently infected districts in the South are brought to the North during the summer, the northern cattle with which they are yarded or pastured will contract the disease and usually die, while the southern animals will remain well. The same fate meets northern cattle shipped into the infected districts.

It has been demonstrated by experiments upon animals, that the cattle tick (*Boophilus bovis*) carries the disease, and that in the absence of this tick southern cattle can be shipped North at any time of year with perfect safety to northern stock, and that if the ticks are removed from the pastures, northern cattle can live in the South. As the carrier of this disease is known, it can be destroyed. Although very promising experiments are now in progress, pointing to a method of immunizing northern cattle against this disease, yet they are of little importance compared with the elimination of the disease. It is partly because of this malady, that an embargo has been put on our cattle by various European countries. With proper state regulations in the infected districts, supplemented by the intelligent efforts of the cattle raisers, these parasites might be eliminated, and that too, within a comparatively few years and at a slight expense. This being accomplished, the cattle of the United States would be free from infectious diseases objectionable to the powers of the old world.

Other diseases.—There are still other diseases, frequently of great local interest, which have been investigated by means of

[1] Ziemssen, 1875.

animal experimentation, and robbed of much of their former terror. Among these should be placed the animal parasitic diseases, such as trichinæ in pork, the fluke diseases of cattle, and the fluke and tape worm diseases of sheep. A nodular disease of the intestines of sheep due to a small round worm, and one in fowls due to a tape worm were once supposed to be tuberculosis. A disease in cattle known as the corn-stalk disease, and which was thought, especially in Europe, to be contagious, and therefore requiring rigid quarantine, has been shown to be due to local causes, and in no way transmissible from one animal to another. Much light has been shed upon the infectious diseases of poultry, such as "black-head" in turkeys and diphtheria in chickens. Very recently a new disease of fowls has been described, a filth disease which is frequently called fowl cholera, and which can be prevented by the adoption of a régime of cleanliness, wholesome food and ventilation. Attention should also be called to the great importance of animal investigations now in progress on various serums, toxines, and antitoxines, for the purpose of discovering efficient remedies for the various infectious diseases of animals.

Zootechny.—In zootechny, or experimentation for improving breeds of domesticated animals, the investigations have been of unquestioned importance to the agriculturist. Whatever the evils from in-and-in or close breeding, no one doubts for a moment that the modern breeds of farm animals are a great improvement over the original and native stock. While the natural resistance of these animals against infectious diseases may have been appreciably lessened, the knowledge we possess of how to keep these diseases away from our flocks, should encourage future experiments for the purpose of raising better and swifter horses; cows to give more and richer milk; sheep to yield finer wool and more of it; and swine to grow more pork per bushel of corn.

Further Investigations Necessary.

A study of the efforts which have been made for the suppression of infectious diseases of animals in this country, shows that, while wonderful advances have been made, the desired results in many instances have not been fully attained. Ignorant of what has been done, and equally ignorant of what there remains to do, there are those who question the necessity for further investiga-

tions. Great as have been the achievements in the past, it must be evident to every unprejudiced mind that still greater achievements, greater whether measured by relief of suffering or by financial gain, are within reach in the near future. The benefits to agriculture and mankind in general, which have accrued from the investigations of the past, are no nearer their maximum limits of success, than was the practical application of steam when Watts made his first discovery. Knowledge of the diseases of animals was practically at a standstill, until the development, by means of repeated experiments upon animals, of the germ theory of disease. The only distinctive advances have been along these lines. In spite of all that has been done, practical preventive medicine has barely passed its infancy, and the important investigations into the dietary diseases have just begun.

So much for future research. A word now in regard to the restrictions of those diseases concerning the causation of which we are no longer in doubt. The application of our present knowledge of detecting diseases and preventive medicine necessitates additional experimentation. How can tuberculosis be eradicated from our dairy herds except by animal experimentation, in testing with tuberculin? How can glanders be eradicated except by the use of mallein for diagnosis? How can we determine in time for treatment, whether the dog which bites a child or farm animal is rabid except by inoculating a rabbit? Disregarding the humanitarian aspect of the case and judging simply from a commercial standpoint, how can we afford to relinquish the investigations which have done so much to assist this country in building up an annual export trade of $176,191,521[1] in animals and animal products with a capital invested in live stock exclusive of poultry of $1,727,926,084?[2]

Furthermore, experiments which have demonstrated important facts to you and to me are not always accepted by others, unless they can be and are verified by repetition. There is in human nature an inherent demand for visible proof. Let me illustrate. It has been demonstrated that the cattle tick (*Boophilus bovis*) causes Texas fever, yet the southern farmer who has always seen ticks upon his cattle does not believe these experiments are true, or at least bear the interpretation put upon them. Within the last

[1] Actual amount of exports of this nature in 1895.

[2] Official estimates of the U. S. Department of Agriculture, Jan. 1, 1896.

six weeks men from the south have requested that these experiments be repeated on their plantations with the assurance that if successfu they will believe in the theory and set about eliminating the ticks. In order not to retard progress, it is often necessary that these doubting Thomas's should be convinced, and the only way to accomplish it is by repeating what has already been done. In other words, a certain amount of experimentation must be carried on as a means of education.

It is evident to all those who are familiar with the methods necessary for the investigation of contagious and infectious animal diseases, that inoculation or exposure experiments are liable to be necessary suddenly at any place and at any time. This renders it exceedingly important that there should be unrestricted liberty in animal experimentation in every state in the Union where farm animals are kept. Such is the existing condition, and to this freedom the American people are very largely indebted for the successes which have been achieved in the suppression of their animal plagues. Owing to an anti-vivisection crusade which finally found expression in a Parliamentary enactment, animal experimentation has been so crippled in England in recent years that the country which should have done most, by virtue of her wide geographical possessions and vast live stock interests, for the improvement of methods of preventing and controlling infectious diseases, has done practically nothing. Let me quote from one of England's foremost veterinarians[2] in a plea for animal experimentation: "No country in Europe has, possibly, sustained greater loss during the last thirty-five years than our own; yet no country, perhaps, should have suffered less. With the finest breed of horses, and the most magnificent herds and flocks in the world, and a teeming population, whose health and wealth are largely centered in these, we have entirely neglected to protect them from the ravages of diseases of home and foreign origin, by forgetting to foster and encourage that science which alone can accomplish this. That neglect has cost Britain and her colonies untold millions."

A similar ill-considered and fanatic crusade is now in progress in this country. At the last session of the present Congress, a bill was favorably reported by the Senate Committee on the Dis-

[2] George Fleming. The Contagious Diseases of Animals; their Influence on the Wealth and Health of the Nation, and How they are to be combated.

trict of Columbia to the U. S. Senate, entitled "*A bill for the further prevention of cruelty to animals in the District of Columbia.*" Ostensibly this bill has for its purpose the prevention of vivisection, which does not exist, in the public schools of the District, but it has been so cunningly worded that if passed, it practically prohibits further investigations into the cause and treatment of animal diseases in the Government laboratories. Not only this, but it virtually closes the highly important laboratory of the Surgeon General of the U. S. Army, and those maintained by the Marine Hospital Service. It is the admitted intention of the promoters of this bill, to use the prestige gained in Congress to assist in obtaining similar prohibitory State legislation. This movement represents an effort, on the part of certain kind hearted and well meaning people to abolish all animal experimentation, but it is not really humane. Its success would entail a vast amount of needless suffering upon animals exposed to the various infectious diseases, and seriously threaten the prosperity of the animal industry of the whole country. To spare the very few experimental animals necessary in procuring life-saving results, they would sacrifice annually tens of thousands of other more valuable animals to all sorts of infectious diseases. The time has come, when the agricultural societies of this country should unite with other scientific and medical associations in protesting against the passage of this inhumane and retrogressive bill. The progress of such investigations as I have here but fragmentarily outlined, and which have the broadest economic and humanitarian value, should not be retarded by misguided sentimentalism.

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The Nature and Prevention of Infectious Entero-Hepatitis in Turkeys.

—BY—

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The Nature and Prevention of Infectious Enteo-Hepatitis in Turkeys.

The farmers of New-England lose annually many turkeys from a disease designated by them as "black-head." This name seems to have been suggested by the fact that the heads of the turkeys become very dark colored during the last stages of the disease. Just when or where this affection first appeared is not known, but at present it is widely disseminated in New-England and it has appeared in a few places in several of the more northern of the western States. Last fall it was recognized in the eastern part of New York. While its gradual migration from New-England westward has been expected, the knowledge recently acquired concerning its nature and cause should enable turkey raisers to adopt more active measures to prevent its future appearance and further dissemination.

The nature of this disease remained a mystery until 1894. During the summer of that year, Dr. Theobald Smith, then of the Bureau of Animal Industry, U. S. Department of Agriculture, made it the subject of special investigation at Kingston, R. I. He found that it was caused by a microscopic organism (*Amoeba meleagridis*) belonging to the lowest forms of animal life. The lesions were found to consist of inflammatory processes in the cæca (prongs) and in the liver. The cæca are first affected, after which the liver, through the portal system of blood vessels, becomes invaded with the micro-parasites. The name assigned to this disease was, in accordance with its pathology, infectious entero-hepatitis.

This disease is of much greater economic importance than is generally supposed. The extent of the losses it occasions can be appreciated from the following statement taken from an article on this subject in the report of the R. I. Agricultural Experiment Station for 1894: "The eradication of this disease would be worth hundreds of thousands of dollars to the eastern farmer alone." As this disease of turkeys has not until recently been known to be of an infectious nature, its spread has been heretofore unrestricted. In fact its dissemination has been unconsciously encouraged by the shipment of turkeys from the infected localities to non-infected sections of the country. As this disease does not ordinarily spread with such rapidity as to cause it to be considered an epizoötic disease requiring prompt attention, it has been able to become well established in the newly infected localities.

Fortunately for its future restriction, and it is hoped, elimination, this disease is easily diagnosed and with a little attention can be differentiated from other intestinal disorders of turkeys. Although the symptoms are not very characteristic, some of them are quite distinctive. The necks of the turkeys usually have a shrunken appearance ; the skin on the head turns to a dark color ; the turkeys become less active and do not keep up with the healthy ones in their daily wanderings ; they soon become indifferent to food and finally die. If the viscera are examined, the walls of one or both cæca will be found to be thickened and perhaps ulcerated. The liver will be enlarged and sprinkled with areas of a greenish, yellowish, or brownish color. These consist of masses of dead tissue and their colors are often exceedingly brilliant. These appearances of the cæca and liver are diagnostic for this disease, as they are not known to occur, or to be even approximated, among the lesions of any other disease of poultry. Further, the specific organism can be discovered if a proper microscopic examination of the affected organs is made.

The channels through which turkeys become infected with the micro-parasite have not been fully determined. It was suggested by Dr.. Smith (Bulletin No. 8, Bureau of Animal Industry, U. S. Department of Agriculture,) that the micro-organism which causes this disease could be transmitted directly from turkey to turkey through the feces or by feeding upon the organs of diseased turkeys. More recently a few experiments made by the Bureau of Animal Industry (Circular No. 5, 1896), shows that this is true. In some of these experiments the feces of diseased turkeys were fed to healthy ones, and in other cases the diseased cæca and livers were cut up in small pieces mixed with the feed and given to healthy turkeys, with the result that nearly all those fed, either feces or viscera, became infected and died with the disease. These experiments demonstrate the fact that this malady can be transmitted directly from affected to healthy turkeys without the intervention of an intermediate host. They do not prove, however, that this is the only way by which it is contracted or transmitted. The theory of the direct transmission is the only hypothesis, however, by which its presence, in many localities, can be readily explained.

Methods of treating the affected turkeys are not promising. Successful medicinal remedies have not been found, and it is highly probable that the only satisfactory method of dealing with this disease is to prevent it. To this end much valuable knowledge has been acquired. Thus it has been shown to be infectious ; its specific organism has been found and described ; and its communicability from diseased to healthy turkeys has been established. The essential preventive measure necessary to be taken by all turkey raisers is to keep, so far as they can with this knowledge, the organism of this disease away from their flock. In purchasing turkeys for breeding or other purposes, care should be taken that they do not come from flocks affected with this disease. If its dissemination through the introduction of turkeys which may be suffering with a chronic form of the affection, or perhaps have been recently infected is checked, it is presumable that this malady will not extend beyond its present boundaries.

It is suggested that farmers and poultry raisers who have recently had this disease in their flocks should dispose of their old turkeys and start by hatching turkey eggs under hens, or with turkeys obtained from non-infected districts, preferably from the South, as this disease is not known to exist there. As a precautionary measure, the turkey roosts, especially the accumulated droppings, should be disinfected early in the spring before the young turkeys are hatched or old ones introduced. The liberal use of slaked lime in the yards most frequently occupied by the diseased turkeys is recommended.

The surest and cheapest method of dealing with infectious animal diseases is to prevent them altogether. This can only be done by closing absolutely the channels through which the organisms producing them gain entrance to the body of the healthy individuals. While there may be an intermediate host for the micro-organism of this turkey disease, the present indications are that there is not, and the best that can be done is to act in accordance with the knowledge that we possess. If the losses annually sustained from this disease are to be reduced and its further geographical distribution to be checked, it is imperative that every one interested should adopt such precautionary measures for its prevention and spread, as actual experiments have demonstrated to be necessary.

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THE HEMOSPAST.

A NEW AND CONVENIENT INSTRUMENT FOR DRAWING BLOOD FOR MICROSCOPIC EXAMINATION.

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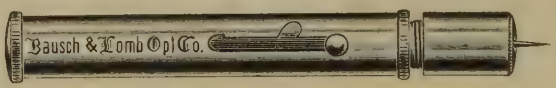
In a recent number of the *Medical Record* I called attention to this instrument as a convenient apparatus for physicians in drawing small quantities of blood for diagnostic purposes. During the past few weeks, however, I have made some important changes in its construction, and which are incorporated in the present description. The constantly increasing attention which is being given to the blood, and the importance of the results of its examination in making diagnoses, renders improvement in the instruments for obtaining even the little blood needed for this purpose worthy of attention. Although a sharp pointed bistoury, a surgical or even sewing needle can be used by the vigorous laboratory student on himself or equally robust companion with little or no discomfort, this little operation has a much more serious aspect to the anemic and usually nervous patient. With these the mere sight of a sharp instrument, although it be but a surgical needle, causes much apprehension. It frequently happens that in the very anemic it is necessary to make several "stabs" before a sufficient flow of blood is secured, and often through a desire to avoid a repetition of the hurt I have seen unnecessarily deep incisions made.

In studying the blood of the smaller or experimental animals in the laboratory the task of getting the blood is less difficult, but even here the incision which is made with a

scalpel, bistoury, or scissors is often unnecessarily long or deep. For the larger animals the spring fleam is very satisfactory, but it is not applicable for the smaller species or for the human subject.

The introduction of the hematocrit for the determination of the number of red blood corpuscles necessitates a slightly larger quantity of blood for each examination than was required for the counting apparatus and consequently aggravates the difficulties, by the present methods, of procuring the required amount. The desire for an instrument with which the incision could be made instantly, and the depth of the cut accurately regulated, led me to make some experiments in the construction of an apparatus possessed of these qualities. The outcome has been a spring needle lancet which works so admirably, and which has so completely removed the difficulties mentioned that it seems worthy of description.



The hemospast[1] consists of a metal tube (I have used brass) about five centimeters long and one centimeter in diameter. The upper end is closed with a milled-edged screw-cap and the lower end covered with a perforated screw-cap, upon which is a second perforated screw-cap about one centimeter long. This forms a regulator for graduating the length of the projection of the cutting needle. A narrow longitudinal slot, two centimeters long, is cut in one side of the tube, beginning one-half centimeter from the lower end. This has a shallow notch cut into the tubing at the top and a deep pocketed one a little below the middle. In the upper part of the tube is a piece of coiled wire spring two and a half centimeters long and of sufficient strength to give the necessary force to a cylindrical plunger carrying the needle, which is

1 Hemospast is the noun from the Greek combination of which the adjective form hemospastic (drawing or attracting blood) is already in use.

placed next to it in the lower part of the tube. The plunger rests against the cap. The incision is made with a triangular-pointed needle inserted and fastened into the lower end of the plunger. A piece of perforated rubber covers the lower end of the plunger and prevents the harsh clicking sound which otherwise would follow the springing of the needle. From the side of the plunger projects a trigger which moves in the slot and with which the plunger is pushed up. When the spring is thus set the trigger is easily caught by a slight twisting movement into the notch at the upper end of the slot. When not in use, the trigger rests in the pocketed notch. By means of the regulator the length of the projecting part of the needle can be easily adjusted. The needle is entirely hidden from sight, so that the instrument, if exposed to view, does not suggest an implement of torture.

In use it is convenient and easily handled. After the finger, or other part, is cleansed and the incision is to be made the spring is set and the instrument is pressed gently to the part, the trigger pushed slightly and the incision of exactly the depth desired is instantly made. As soon as sprung the hemospast can be dropped and the collection of blood begun.

This instrument is equally efficient and much more convenient in procuring small quantities of blood from experimental animals than those which I have heretofore observed in the hands of others or employed myself. As it is made entirely of metal it can be sterilised as other surgical instruments. If desired, it can be made larger and stronger with needles of various sizes and, if preferred, with a cutting edge of a millimeter or more in length. It is available, therefore, for workers in laboratories where normal human blood or that of healthy or diseased animals is being studied, as well as for the practising physician. Although simple in its design, there were a few mechanical difficulties encountered, for the overcoming of which I am indebted to Mr. W. C. Barnard for timely suggestions.

POWDERED SOAP

AS A CAUSE OF DEATH AMONG

SWILL-FED HOGS.

By Veranus A. Moore.

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CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION,
1897.

POWDERED SOAP AS A CAUSE OF DEATH AMONG SWILL-FED HOGS.

It is a common experience of those who are engaged in the investigation of animal diseases to occasionally find outbreaks of a peculiar nature among swill-fed hogs. By these are meant herds of greater or less size, usually kept near or within the outskirts of our villages or small cities, and which are fed upon the kitchen refuse, often including the dish water, collected from hotels, boarding houses and private dwellings. The cause of death in these outbreaks is, in this state, at least, usually attributed to hog cholera. The basis for this popular diagnosis seems to be in the similarity of certain of the symptoms manifested by these animals to those of hog cholera, such, for example, as diarrhœa and partial paralysis and the fact that a majority of those attacked die. The course of the disease is irregular, deaths occurring in from a few hours to several days after the symptoms appear.

During the past year I have had occasion to make investigations into the nature of several of these outbreaks of a supposedly infectious disease. In a few of these epizoötics hog cholera or swine plague was easily demonstrated. In certain others, however, these or other infectious diseases could not be found. The animals were usually fed the kitchen slops collected from hotels and boarding houses. The tissue changes in the animals examined were atypical of any known disease and notwithstanding the bacteriological examinations which were made, together with animal inoculations with pieces of the diseased organs, the cause of death remained undetermined. The post mortem examinations showed in nearly all of these animals enlarged and dark colored lymphatic glands, especially those of the mesentery. The blood vessels of the mesentery were very much distended with blood. The liver and kidneys were usually not affected but occasionally these organs were involved. Where there had been

marked nervous symptoms the brain was much congested. Occasionally the lungs contained areas of collapse. The intestines were, as a rule, pale and the mucous membrane seemed to be abnormally shiny.

The negative outcome of these investigations suggested that possibly our methods had been faulty or that some unknown conditions existed which had obscured the cause of death, and that after all the popular diagnosis of an infectious disease was right. Against this theory was the fact that the disease did not spread from the affected herds to others, although, as a rule, precautions were not taken to prevent its dissemination and in some instances the neighboring herds were most favorably situated for contracting the disease if it had been contagious. In certain of the outbreaks the exceedingly filthy condition in which the pens and yards were kept suggested, in the absence of a knowledge of definite, specific agents, that the animals had died as a result of their unsanitary surroundings and unwholesome food, a hypothesis which in some instances is still entertained as being highly probable. However, we were still confronted with the problem that in many outbreaks neither a specific infectious disease could be found nor the exciting cause of death pointed out.

Although it was apparent that the cause of the deaths was to be found in the food, the feeders of this kind of swill failed to see why they should discontinue its use. Naturally they felt that if we could not find or demonstrate the presence of the destructive agent in the swill the cause of death must be something else, probably hog cholera, for thousands of hogs are annually raised upon this kind of food. Further, the plea that such garbage was not a suitable or even wholesome food for their animals availed nothing for the reply was, that usually their pigs thrived upon it.

Early in the summer, in conversation on this subject with Mr. W. F. Davey, an enterprising farmer living near Brewerton, N. Y., he related the circumstances concerning an outbreak of this kind in which he had traced the cause of the trouble to the soap used in washing the dishes. The swill, including the dish water, was collected from three small hotels and fed to a herd of swine. In a short time the animals began to sicken and many of them died.

Upon inquiry it was found that in the hotels large quantities of powdered soap were used in washing the dishes. This was stopped and no more animals died. Later in the season Dr. J. A. McCrank, of Plattsburg, told me of an outbreak of an apparently infectious disease among swine which had come under his observation and in which he could not make a positive diagnosis. In the investigation of its cause he found that the hogs were being fed the swill, including the dish water, from a hotel. Upon inquiry he found that powdered soap was being used in large quantities. The swill from this place was stopped and the disease disappeared.

In following up the line of inquiry which these experiences suggested, it was found that there is among the more enterprising farmers, a quite general belief that these soaps, when given in considerable quantities, are injurious and even fatal to hogs. The consensus of opinion on this subject together with the more definite observations of Mr. Davey and Dr. McCrank appeared to be so conclusive that it seemed important to determine by careful experiment to what extent, if at all, powdered soaps can be considered as the cause of death in this class of outbreaks. To this end the experiment about to be described was carried out. It shows that when certain of the powdered soaps sold in the market are present in the food in relatively large quantities a considerable percentage of the animals will sicken and many of them will die. When, however, the soaps are added to the food in small quantities (a dessert spoonful in the food for three pigs, twice daily) no bad effects seem to follow. The cause of death when it does occur is probably due, as shown by the chemical analyses, to the free alkali, sodium carbonate or washing soda, which they contain.

EXPERIMENT IN FEEDING POWDERED SOAPS TO PIGS.

In the experiment three of the commonly used powdered soaps were selected. They are here designated as soaps A, B and C. Nine pigs weighing about 20 pounds each were taken. They were given their regular food, grain mixed in water and some separator milk. To this was added a definite quantity of the

soaps which were dissolved and thoroughly mixed in the food twice daily.

SOAP A.

July 10. Pigs Nos. 1, 2 and 3 were placed in pen No. 1. They were given, night and morning, regular rations as previously described to which were added 2 ounces of soap A.

July 14. Pigs well. Quantity of soap given increased to 4 ounces.

July 18. Pig No. 1 has profuse diarrhœa, others well.

July 20. Pig No. 1 has diarrhoea, at times it runs about the pen in apparently a dazed condition.

July 24. Pigs Nos. 1 and 2 have bad diarrhœa. Quantity of soap given reduced to 1 ounce.

Aug. 1. Pigs appear to be well.

Ang. 7. Quantity of soap increased to 5 ounces.

Aug. 8. Pigs sick, all have diarrhœa, do not eat. Have some difficulty in walking.

Aug. 9. Pigs appear to be no better.

Aug. 11. Pigs still sick. Have eaten very little. Soap stopped.

Aug. 12. Pigs slightly better.

Aug. 15. The condition of the pigs is much improved.

Aug. 18 Animals apparently well.

The feeding of this soap was repeated on these animals some weeks later with a similar result.

SOAP B.

July 10. Pigs Nos. 4, 5 and 6 were placed in pen No. 2. They were fed the regular rations to which were added, morning and evening, 2 ounces of soap B.

July 14. Pig No. 4 has a bad diarrhœa. Others well. Quantity of soap given increased to 4 ounces.

July 15. All three have a diarrhœa.

July 19. Pig No. 4 found dead. No. 5 very sick, unable to stand, refuses food.

July 20. Pig No. 5 can not stand, limbs constantly jerking. There seems to be paralysis. It dies late in the afternoon. Pig No. 6 has suffered from diarrhœa but otherwise seems to be well although it eats very little. Quantity of soap reduced to ½ ounce.

July 22. Pig No. 6 better.
Aug. 1. Pig No. 6 much improved. Soap discontinued.

SOAP C.

July 10. Pigs Nos. 7, 8 and 9 were placed in pen No. 3. They were fed the same as the others. Night and morning 2 ounces of soap C were mixed with their food.
July 13. All the pigs have diarrhœa, eat very little.
July 14. Quantity of soap reduced to 1 ounce.
July 16. Pigs very sick. Eat very little, head jerks constantly, limbs tremble, temperature 103.5, 104, 103.8° F.
July 18. Pig No. 7 dies suddenly to-day. Others still sick. No. 8 has much difficulty in standing, Lies with feet extended. Legs and head are constantly jerking. No. 9 has diarrhœa, eats little but otherwise appears to be well.
July 19. Pig No. 8 found dead this morning. No. 9 seems to be better.
July 20. Pig No. 9 eats heartily. Appears to be quite well.

Three other pigs, Nos 10, 11 and 12 from the same lot were placed in pen No. 3 with pig No. 9. They were given ½ ounce of soap C thoroughly mixed with their food twice daily.

July 25. Pigs apparently well.
Aug. 1. Pigs apparently well.
Aug. 17. Pigs apparently well. The quantity of soap increased to 4 ounces at each feeding.
Aug. 18. Pig No. 10 sick.
Aug. 20. Pigs all sick, refuse food. They ate sparingly of some corn given them.
Aug. 21. No appreciable change.
Aug. 23. Pig No. 10 very sick. The muscles of the head and legs constantly jerking. Eats very little of the regular food but partakes sparingly of corn.
Aug. 25. No change.
Aug. 27. Pigs very sick, have refused food containing soap for two days. Eat sparingly of corn. Soap discontinued.

The pigs which recovered from the immediate effect of the soap did not become thrifty for some weeks. It was late in September before they began to show signs of growth.

POST MORTEM EXAMINATION.

Pig No. 4. The skin over the ventral part of the body and between the thighs of a pinkish color. Kidneys very pale. Spleen normal. The blood vessels of the mesentery much congested. The mesenteric glands enlarged and oedematous. Many of them are congested. Areas of the mucous membrane of the intestines especially the ileum, were of a dark reddish color. The lungs and heart were not changed. The brain was deeply congested.

Pig No. 5. This pig showed lesions very similar to those exhibited by No. 4. The essential difference was an increase in the intestinal congestion.

Pig. No. 7. The skin between the thighs and about the nose was of a bright pinkish color. The liver was small. exceedingly firm and friable. The mesenteric blood vessels were injected and the mesenteric glands were enlarged and oedematous and many of them deeply reddened. A few were hemorrhagic. Spleen normal. The cortex of the kidneys very pale but the papillae were abnormally dark. The mucous membrane of the intestines was congested in a few irregular areas. The mucosa of the stomach covered with a thick layer of mucus. The heart and lungs were normal in appearance. The brain was very much congested.

Pig No. 8. The tissue changes in this animal were similar to those found in pig No. 7 with the exception that the kidneys were much congested.

A careful bacteriological examination was made of the liver, spleen, kidneys and blood of each animal that died. In nearly every instance (all but two) the tubes of culture media (agar and bouillon) inoculated remained clear. The two exceptions contained saprophytic bacteria and were probably contaminations from the air. This examination shows that the alkali had not favored the migration of the bacteria from the intestine to the various organs of the body.

In order to check the results, several pigs from the same litters as those used in the experiment were kept, in adjacent pens, and given the same kind of food. They all remained well. This fact in addition to the negative results from the bacteriological examination, and the peculiar nature of the lesions are sufficient evidence that the sickness and the fatalities among the pigs in the experiment were due to the soaps administered.

It is important to note that the lesions found in the pigs which died in the experiment were similar to those found in the pigs in certain of the outbreaks mentioned among swill-fed hogs. Considering the facts as they appear, it seems highly probable that the cause of death of the animals in certain of the outbreaks mentioned was the presence of the free alkali in the swill. This hypothesis is supported by the experiences of Mr. Davey and Dr. McCrank.

Chemical Analysis of the Soap Powders Used.

In order to ascertain the chemical nature of these soaps they were submitted to Mr. Geo. W. Cavanaugh, Assistant Chemist of the Agricultural Experiment Station for analysis. The following report was received :

"The soap powders used in the above experiment are mixtures of ordinary hard soap that has been powdered or in some way reduced to a fine condition, and sodium carbonate. Sodium carbonate is known in commerce, as Sal Soda, Washing Soda or Soda. In water it forms a caustic solution which is the lye used in making the old-fashioned hard soaps.

Analysis.

Soap A.....49.60 per cent.
Soap B.....55.42 per cent.
Soap C.....55.54 per cent.

(Signed) Geo. W. Cavanaugh, Asst. Chemist."

A careful inquiry has been made to ascertain the quantity of these soaps commonly used in washing dishes. This has revealed the fact that while the amount used by different individuals varies, the quantity is large, usually far in excess of the amount prescribed by the manufacturers. Thus I have been told, by thoroughly reliable people, of dish washers who would use one-

third of a box in cleansing the dishes after a single meal. While this is extreme, it is said not to infrequently happen, and it is easy to understand that the swill from these kitchens would contain far more of the alkali than we found necessary to produce fatal results. Should such excess in the use of these cleaning agents be indulged in for several days in succession, we have, in the light of the foregoing experiment, a cause for many fatalities among the hogs fed upon the dish water.

In view of this danger it seems better to abandon altogether the habit of giving dish water to hogs. Although the feeding of garbage is generally condemned, the scraps of vegetables and table refuse could, perhaps, if properly collected be used with safety. But certainly pure water is a much more wholesome drink, even for swine, than dirty dish water. When the subject of "swill feeding" as a business is studied and the conditions as they exist are understood the wonder is, not that some of the hogs die, but rather, that any of them live.

It is not presumed that the poisoning by carbonate of sodium, is the only cause of death among swill-fed hogs. Other destructive agencies are liable to be found in the decomposing garbage. The results of the investigation which the necessity of good farm hygiene demands will very likely disclose the specific nature of many of them. Another fact worthy of consideration is that the investigation of the last year shows that nearly all of the outbreaks of hog cholera and swine plague which came to our attention started among herds of swine fed upon garbage and swill collected from the sources above mentioned. This is significant and it points to the undesirableness of feeding garbage to animals. In fact if the total losses it occasions are counted, it is questionable if anything is gained in this attempt to save waste products. It is stated in the official reports of the U. S. Department of Agriculture that in 1896 12 per cent. (which amounts to 5,440,176) of the hogs in this country died from disease.

Again it has long been recognized that the feeding of garbage to hogs furnishes one of the most favorable channels for the introduction of hog cholera and swine plague bacteria. As a rule, wherever we find hogs in clean, well ventilated pens and fed upon wholesome food we find thrift and health, and con-

versely, where these animals are surrounded with disgusting filth and fed upon decomposing slops or other unwholesome food we expect to and often do find disease.

It is unfortunately becoming a too prevalent habit among our farmers to assume, as soon as one or two pigs die that some infectious disease, such as hog cholera, is among them. It is further most unfortunate that they frequently entertain the fatalistic notion that a remedy is beyond their reach. Fully 25 per cent of the outbreaks of reported hog cholera which we have investigated during the past year have not been hog cholera or any other known infectious disease. While it is true, that when hog cholera becomes well established in a herd there is great danger that the majority of the animals will die, it is equally true that if the disease is not a genuinely infectious one that a majority of the animals can, by proper treatment, be saved. When a pig sickens and dies the thing to do is to examine, or have it carefully examined, to find out if possible what the cause of death is, in order that the best methods known for preventing the further spread of the disease may be promptly adopted.

If the examination shows the disease to be hog cholera, swine plague or any other infectious disease like anthrax or tuberculosis the as yet uninfected and apparently well animals should be placed in other pens and the old ones disinfected. The animals should be given easily digested and nourishing food, plenty of sunlight and pure air. If others should become affected, the well ones should again be separated from the sick. The channel or way by which the specific cause of the disease got into the herd should be diligently sought for. As the most common way is through the food it is always a safe precaution to change the diet.

It is certainly not desirable to acquire the reputation of having an infectious disease among one's animals when the real trouble is due to poor hygiene, to some irregularity in their care, or to an accidental poisoning.

If the diagnosis can not be positively made it is best to put the apparently well hogs in a separate pen, provide them with good ventilation, wholesome food and cleanliness. *It is important that the food should be changed.* By carefully observing the method of *strict isolation*, disinfection, healthful surroundings and nourishing

diet many epizootics of infectious diseases have been checked and it is safe to presume that if such precautions were rigidly adhered to nearly all of the losses now sustained from dietary causes would be saved. The observance of the rules necessary for the promotion of good health among mankind apply with equal force to the lower animals.

CONCLUSIONS.

From the foregoing the following conclusions seem to be warranted.

1. The greatest amount of loss sustained from swine diseases in this state is among hogs fed upon the swill collected from hotels, boarding houses, and other large institutions.

2. The cause of death in certain outbreaks of disease among swill-fed hogs is the direct poisoning of the animals by the excess of free alkali (washing soda) in the swill. These alkalies come from the powdered soaps used in washing dishes.

3. It appears that small quantities of the powdered soaps do not produce immediate bad results. It is presumable that they can be used in quantities sufficient for the needs of cleanliness with perfect safety, but owing to the danger involved in their use it is safer not to give the water containing them to animals.

4. In addition to the unwholesomeness of garbage and kitchen slops for animal food, and in addition to the losses sustained from the immediate effect of such kinds of food, hogs fed upon it are very liable to contract specific infectious diseases such as hog cholera, swine plague and tuberculosis.

5. The enormous amount of loss among garbage fed hogs, which in this state alone aggregates thousands of dollars annually, suggests the desirability of urging the discontinuing of the practice of collecting swill for such purposes. Certainly if the refuse material is to be used for feeding swine it should be collected and fed while fresh and sweet. When possible, it should be kept dry, and by all means free from alkaline dish water. It is advisable to cook all kitchen or table refuse before feeding in order to remove the danger of infection from specific diseases. The only suitable channel for the disposal of dish water is the sewer.

New York State Veterinary College,
Cornell University, Ithaca, N. Y., Oct. 20th, 1897.

BLOOD SERUM IN THE PREVENTION AND TREATMENT OF INFECTIOUS SWINE DISEASES WITH A REPORT OF AN EXPERIMENT WITH SWINE PLAGUE ANTITOXIN.

By Veranus A. Moore.

(*From the Proceedings of the Eighteenth Annual Meeting of the Society for the Promotion of Agricultural Science held at Detroit, Mich., August, 1897.*)

BLOOD SERUM IN THE PREVENTION AND TREATMENT OF INFECTIOUS SWINE DISEASES WITH A REPORT OF AN EXPERIMENT WITH SWINE PLAGUE ANTITOXIN.

BY VERANUS A. MOORE.

Investigations aiming at the discovery of methods for the production of immunity against hog cholera and swine plague have their origin early in the history of bacteriology in America. In the beginning, the outlook for practical results was very promising, especially after the discovery, in 1885, by Salmon and Smith[1], that pigeons could be made resistant to hog cholera by the subcutaneous injection of sterilized bouillon cultures of the hog-cholera bacillus. In a paper read before the Biological Society of Washington, D. C., April 4, 1891, the writer pointed out the fact that similar results could be obtained in guinea pigs, but that rabbits did not respond in like manner to the same treatment. Investigations along these lines were continued in the Bureau of Animal Industry until a considerable number of series of experiments in which the living culture, sterilized bouillon and agar cultures, sterilized blood from affected animals, and the serum from immune animals were employed in various ways for the purpose of immunizing guinea-pigs, rabbits, and swine against these diseases. The results of certain of these investigations, begun in 1889, were published five years later.[2] They show that guinea-pigs and rabbits could be immunized against these diseases by certain processes, but that frequently there was quite a difference in the results of parallel experiments. They demonstrated the important facts that there is a marked difference in the production of artificial immunity between the two diseases, as well as

[1] Second annual report of the Bureau of Animal Industry, U. S. Department of Agriculture, 1885.

[2] Theobald Smith and Veranus A. Moore. Experiments on the production of immunity in rabbits and guinea-pigs with reference to the hog-cholera and swine-plague bacteria. Bulletin No. 6, Bureau of Animal Industry, U. S. Department of Agriculture, 1894, p. 41.

between these species of animals. Of the two, resistance to swine plague was more easily obtained than to hog cholera. They showed, further, that the blood serum of these animals, after they had become immune to these diseases, was not more efficacious in the production of immunity in these species than the sterilized cultures. It was also observed that the toxicity of sterilized cultures appeared to be directly proportional to the number of bacteria in the injected liquid. The most potent immunizing agent, especially for swine, found in these experiments, was a sterilized suspension of the growth of the hog-cholera bacillus on a solid medium (agar).

Another point of interest, not only from the immunity standpoint, but also from the differential diagnosis of the two diseases, was the demonstration of the fact that guinea-pigs made insusceptible to swine-plague bacteria, offer no resistance to hog-cholera bacteria and *vice versa*. As will be shown later, this has a very practical bearing in the use of therapeutic serums in swine diseases.

In 1890, de Schweinitz,[3] of the biochemic laboratory of the Bureau of Animal Industry, published the results of experiments in the production of immunity with the chemical substances (Sucholotoxin and sucholo-albumin) which he had isolated from pure cultures of hog-cholera bacteria. He summarized his results in the following statements:

"That in guinea-pigs, complete immunity from hog cholera can be produced by chemical inoculation. The sucholotoxins and sucholo-albumin are equally effective in this respect, and a mixture of these two products gives greater immunity than either used by itself." * * * In a later paper[4] he published the results of experiments made upon guinea-pigs with the serum from a guinea-pig which had been immunized to hog cholera. This article indicates that he experienced little or no difficulty in obtaining positive results in this species of animals.

In 1892 Metschnikoff[5] stated that immunity could be easily pro-

[3] The *Medical News*, October 4, 1890.

[4] The *Medical News*, September 24, 1892.

[5] Etudes sur l'Immunite (5 memoire); immunite des lapins vaccines contre le microbe du hog-cholera. Annales de l'Institut Pasteur, VI., 1892, p. 289.

duced in rabbits towards hog cholera with the blood serum from immune rabbits. Later Dr. Smith[6] received a culture from Metschnikoff of the bacillus with which he had worked, and which proved to be that of swine plague and not of hog cholera. This harmonized the results obtained by Smith and Moore with those reported by the eminent French investigator, namely, that rabbits are easily immunized to swine plague.

In applying the methods found to be fairly satisfactory in the production of immunity in these experimental animals to hog cholera and swine plague, to swine themselves, very unsatisfactory results have almost invariably been obtained. The use of small quantities of the living culture were likewise untrustworthy, notwithstanding that attenuated living cultures have been found quite efficacious in rendering animals resistant against certain other diseases. Concerning the use of living virulent cultures, there has been some difference of opinion. Billings, formerly of the Nebraska State Experiment Station, advocated the value of preventive inoculation, but experience has taught that this procedure is not practical, and the method has been abandoned.

Serum Therapy in Infectious Swine Diseases.

As methods for the production of immunity did not, after years of the most untiring and careful investigation, reach a practical basis, attention has been directed to the treatment of these diseases by means of the blood serum from immunized animals. The successes obtained with the diphtheria and tetanus antitoxins suggested that, perhaps, similar results might be realized with the swine diseases, and already there has been much activity exhibited in exploiting the possibilities of this new field. Many of the efforts appear to have been fruitless, but others are giving promise of success. The fact should not be lost sight of, that in these diseases, more perhaps, than in any others, there are complications by way of mixed infection, and the effect of unwholesome food and bad environment which may materially change the neutralizing action and the final result of the antitoxin of either of the diseases.

[6] Loc cit.

Lorenz[7] seems to have been the first to use serum therapy on swine with success. He worked, however, with *rouget*. After immunizing guinea-pigs and rabbits against this disease, he used their blood to immunize swine. This being successful, he used their blood in immunizing other swine. The method is reported to be fairly satisfactory.

In the fall of 1896 two papers on serum therapy in American swine diseases appeared, which indicate that at least some of the difficulties heretofore experienced in the direct use of the bacterial products are being overcome. The first of these was read before this Society by Dr. E. A. de Schweinitz[8] of the Bureau of Animal Industry. He used antitoxin serum which was prepared by repeatedly inoculating a cow. With the blood serum of this animal, positive and constant results were obtained in guinea-pigs. The amount of this antitoxin required was 6 c.c. per pound weight of guinea-pig. We are promised, in the paper, a full and detailed account of this and other experiments in this line.

Dr. A. T. Peters[9] of the Experiment Station of Nebraska, presented the other communication before U. S. Veterinary Medical Association. He inoculated horses with virulent cultures of the hog-cholera bacillus, beginning with 5 c.c. and increasing the quantity until 200 c.c. was given at a time without apparent discomfort. After the animal ceased to react to the cultures, a small quantity of the blood was drawn and tested on rabbits after the method used in testing diphtheria antitoxin on guinea-pigs. When the horses were sufficiently immunized, their serum was tried on swine. His laboratory experiments show that it took from 8 to 10 c.c. of the undiluted serum to make a hog weighing 150 pounds immune to hog cholera. At the writing of his paper, the serum had been tried in about 23 herds reported to be affected with hog cholera. From several of these, encouraging results had been obtained.

The criticism on the paper, as brought out in the discussion

[7] *Deutsche Zeitschrift für Thiermedicin*, Bd. XX.

[8] Proceedings of the Society for the Promotion of Agricultural Science, 1896, p. 47.

[9] Serum therapy in hog cholera. Proceedings of the U. S. Veterinary Medical Association, 1896, p. 159.

which followed it, is, that positive evidence of the accuracy of the diagnosis of the disease in the herds in which the serum was used, was not procured. Further, the usual mortality in similarly affected herds which were not treated is omitted. If the disease which he treated in the field was genuine hog cholera, his results were quite reassuring.

Soon after the publication of the last mentioned papers, Perroncito[10] announced the discovery of a vaccine for hog cholera. This, I am told, is a blood product. It has become an article of commerce without having, to my knowledge, its efficiency verified for the disease as it occurs in this country. From the notice and circulars sent out, 3 c.c. is the dose. In France it is stated that the sale of serums is authorized by law only after the Academy of Medicine has given its approval to samples and inspected the laboratories where they are made, but we are not similarly protected either by State or national laws.

A Field Experiment with the Swine Plague Serum Prepared by the Bureau of Animal Industry.

In January last, I had occasion to make an investigation into the nature of an infectious disease which was destroying many swine in a herd near Auburn, N. Y. The history of the herd and the appearance of the disease up to this time, as related by the owner of the animals, is briefly stated as follows :

The herd consisted of 72 animals, mostly shoats, some of which had been purchased in the vicinity and the others raised on the place. They had run together about the premises until late in the fall. Early in December they were divided into three lots and penned.

In pen No. 1 were 14 yearling hogs weighing about 250 lbs. each.
In pen No. 2 were 37 black and white shoats weighing about 60 lbs. each.
In pen No. 3 were 21 white shoats weighing about 40 lbs. each.

Pens Nos. 1 and 2 were in the same building, but separated by a tight partition and several feet of floor space. Pen No. 3 was

[10] Noticed in Recueil de Médecine Vétérinaire, VI. (1897), p. 71.

a building by itself standing about 300 feet from the first. The animals had been and were still being fed on swill obtained from the State prison at Auburn. Late in December the pigs in pen No. 1 began to sicken and die. The symptoms were said to be the refusal of food and a bad cough which developed a few days before death. A little later the older hogs in pen No. 1 were attacked and 9 of them died.

At the time of my first visit (Jan. 28) about 40 animals had died. Those which I found living were in pens as follows :

In pen No. 1, there were 5 hogs all apparently well.

In pen No. 2, there were 4 pigs all sick.

In pen No. 3, there were 19 pigs all apparently well.

In pen No. 4, there were 2 pigs which had been taken from pen No. 2, after the disease had appeared. They were well.

In pen No. 5, there was 1 pig which had been taken from pen No. 3, because it looked sick.

The hogs had died at the rate of one or two a day after a sickness of from a few days to three weeks duration. I found two dead hogs from pen No. 1. They had been dead about ten and twenty-four hours respectively. Just before my arrival one of the pigs from pen No. 2 had been killed, in what was thought the last stages of the disease, by Mr. Quigley, state inspector, and sent to me by express. It was received and examined the following morning. The two old hogs were carefully examined at the time.

The lesions found in both of these animals were extensive hepatization of the lungs. In both animals the cephalic, ventral, and a portion of the principal or caudal lobes were involved. In one of them there was extensive pleuritis. The spleens were slightly enlarged and dark colored. The mesenteric glands were enlarged and hyperaemic, in a few instances the cortex was hemorrhagic. This was especially true with those along the smaller curvature of the stomach. The intestines presented a few areas of hyperaemia, but no distinct lesions. Tubes of agar inoculated from the spleen and lungs gave pure cultures of swine plague bacteria. Rabbits inoculated with pieces of the hepatized lung died of swine plague on the fifth day. Those inoculated with the culture died in a shorter time.

The small pig did not show any decided lesions. Cultures made from its organs either did not develop or they contained impure growths of saprophytic bacteria.

As the disease appeared to be swine plague, though probably of a sporadic form, it seemed to be a suitable outbreak in which to try the serum therapy. Prior to this I had been requested to try this serum if an opportunity occurred. And while this was by no means the ideal time in the course of the outbreak to begin, it was thought best to try it. Unfortunately only a small quantity of the serum was obtainable at this time.

Feb. 11, I again visited the outbreak in company with Mr. Quigley. We found that no deaths had occurred during the interim, but that the disease had appeared in pen 3 and three of the pigs were very sick. Those in pen 2 were about the same as when last seen. As I had but 11 doses of the serum, the following animals were injected. In selecting these the wishes of the owner were largely observed.

In pen No. 1, 2 hogs received subcutaneously 24 c.c. each.
1 hog received subcutaneously 12 c.c.
2 hogs were reserved for checks.

In pen No. 2, 4 pigs received subcutaneously 12 c.c. each.

In pen No. 3, 3 pigs received subcutaneously 12 c.c. each.
These were sick. They were removed to another pen.

In pen No. 5, 1 pig received subcutaneously 12 c.c. Sick.

Feb. 18, I again inspected the animals and found three of the treated ones dead. These were: 1 from pen 2; 1 from pen 3; and the one in pen 5. They were examined carefully post mortem and the lesions found were indicative of swine plague. The lungs were more or less hepatized. The spleens were slightly enlarged and the mesenteric glands were somewhat oedematous. The intestines were normal in appearance. From two of the animals the swine plague bacillus was obtained. Cultures were not made from the third on account of post mortem changes. The remaining pigs in pen No. 2 were no worse, and the other two from pen No. 3 were decidedly better. There had been no other deaths.

February 27 I found a second pig dead from pen No. 2. The

disease had again appeared in pen No. 3 and one animal had died. The post mortem examination of these two pigs showed extensive lung disease. The intestines were not affected. Rabbits inoculated with bits of the lung tissue of the pig from pen 3 died on the sixth day, with attenuated swine plague, as shown by the extensive pleuritis.

At the request of the owner, more of the serum was obtained and on March 1 the remainder of the pigs in pen No. 3 were treated. During the time two of them had died, leaving but 13 still living. More than half of these were coughing. They were all injected subcutaneously in the groin with 12 c. c. each of the swine plague serum. The two dead pigs were, for want of time, hurriedly examined and the lesions found to be restricted to the organs in the thoracic cavity.

During the next two weeks, five of the last treated pigs died. They were not examined as word of their death was not received until some days later. The remaining eight remained well or recovered, and subsequently they were reported as growing nicely. I saw them the latter part of April and they looked perfectly well. The two survivors of the first lot of three from this pen recovered rapidly. Later the remaining two pigs in pen No. 2 died. None of the hogs in pen No. 1 were attacked after the treatment. They were sold late in March.

To summarize, there were at first 11 animals treated, of which 8 were obviously sick at the time they were given the serum. Of these 6 died. Later 13 others were injected. Of these 8 were obviously sick at the time of treating and 5 died. Of the total of 24 treated animals, 11 died and 13 survived.

In drawing conclusions from this experiment several facts must be taken into consideration. Although all of the animals were not examined, there were enough post mortems to show that the disease was very probably uncomplicated swine plague. It did not spread, however, to other herds in the locality and a neighbor fed swill from the same source to his hogs without loss.

At the time the treatment began, 40 animals had already died, so that among the survivors we may have had those possessed of stronger resisting power. Again, the virus obtained from the different animals was of the attenuated variety, showing that

possibly the disease was well nigh spent at the time the treatment was begun.

On the other hand, the disease in pen No. 3 did not appear until just before the treatment. The owner had tried to keep these animals isolated from the others, but in spite of this there was much running, by the farm hands, from pens 1 and 2 to this one. The perfect recovery of two of the very sick pigs first treated, from pen No. 3, is very suggestive of a specific action on the part of the serum. Again, all of the animals attacked, and which were not treated, died, while of the 24 treated at least 16 were obviously sick at the time, and of these at least five recovered. The pigs did not receive the care either in protection from the cold and wet or in their food which good farm hygiene demands. All things considered, therefore, the results are, if taken at their worst, encouraging.

It is difficult to draw further conclusions from this experiment or the results of others herein referred to. Just what the action on the animal body of the toxin injected is, by which it is converted into an antitoxin has not as yet been satisfactorily explained. The investigations have not advanced sufficiently to enable us to say what species of animals will furnish the best antitoxin, but if it is to become practicable it seems that it must be one of the larger, such as the cow or horse. The question has also arisen, whether or not the method will be practicable even if the serum can be made efficient. To this a positive answer can not be given, but it seems highly probable that it can. It is easily administered, and the cost of its preparation ought not to preclude its use. It is suggested by the work on guinea-pigs that the serum for hog cholera and swine plague can not be made interchangeable, neither can they be made a specific for dietary and filth diseases. These must be eliminated by the introduction of better sanitary methods. From the successes reported from serum therapy in other diseases it is reasonable to expect, that eventually we may have antitoxins for the bacterial diseases of swine. Certainly, the results of the experiment just described indicate that the investigations along these lines are more promising than any others which have been proposed for the discovery of a specific for swine plague.

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REMARKS ON THE NATURE AND THE DIFFERENTIATION OF THE INFECTIOUS SWINE DISEASES IN THE UNITED STATES.*

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We sometimes hear that there is much confusion concerning the knowledge of the infectious swine diseases in the United States. Perhaps for a brief time early in the history of their investigation, this was the case, but at present our pathologists are, with possibly a very few exceptions, agreed on their morbid anatomy and etiology. There appears, however, to be an element of uncertainty concerning them entertained by a few writers, more especially among those who have not had an opportunity of studying them as they exist in epizootic form. The fact must be admitted, therefore, that while these diseases have been clearly defined in the official reports of the Bureau of Animal Industry, U. S. Department of Agriculture, and by pathologists and bacteriologists in other institutions, there have appeared, both at home and abroad, statements of a contradictory nature which have tended to confuse the reader of the recent literature upon this subject. The difficulty, however, is in the interpretation rather than in the lack of the existence of definite knowledge concerning the nature and cause of these maladies. Although our knowledge of their natural history is far from being complete, no one familiar with the facts, as they are recorded, can feel that American swine diseases have not been carefully investigated.

As the advance in human medicine depends so largely upon the results of comparative and experimental pathology, it is

* Read before the Section of Pathology and Bacteriology of the British Medical Association at the Montreal meeting, Sept., 1897.

highly important that the nature of the maladies in question should be clearly understood, for among animal diseases there are none which are more analogous to certain human affections than these bacterial plagues of swine. If the suggestion that this subject should be opened for discussion was correctly interpreted it was for the purpose of having some of the essential features of these diseases, as they have been determined by American investigators, again pointed out that their differences and their independent existence could be more fully appreciated. As I understand the situation all elements of confusion will be removed if the following questions can be clearly and fully answered:

1. Concerning the nomenclature of infectious swine diseases in Europe and America. Which of the names given to the diseases of swine are synonyms of hog cholera, which of swine plague, and which represent other affections?

2. Concerning their morbid anatomy. What are the lesions characteristic of hog cholera and what are those diagnostic of swine plague?

3. Concerning their etiology. What are the morphological characters, biochemic and pathogenic properties by which the hog-cholera and swine-plague bacteria can be differentiated?

In a paper of this length it is impossible to answer these questions in detail, but it is hoped that some of the essential truths may be pointed out and that references * may be given to such papers and reports that any who may desire, can find the entire story, as it is known at the present time, in our most authoritative publications.

In the United States of America two infectious diseases peculiar to swine have been described under the names of hog cholera and swine plague. The third malady—swine erysipe-

* In citing the literature, reference is made simply to the more important papers giving the results of original investigations which have been made in this country. The criticisms, controversial writings and more popular articles must, for want of space, be omitted. An abstract of nearly all the papers relating to these diseases may be found in the Jahresbericht über die Leistungen auf dem Gebiete Veterinär-Medicin, and also in Baumgarten's Jahresbericht, 1885-1896.

las, *rouget* or *Rothlauf*—peculiar to this species has not been found to be the cause of destructive outbreaks, although an organism closely related to, if not identical with, the bacillus of rouget has on at least three occasions * been isolated from swine. In each of these instances it was obtained from one animal only. Omitting, therefore, from this discussion this possible, but as yet in America unrecognized disease, we pass to the consideration of the two maladies first mentioned.

The investigation into the nature and cause of infectious diseases among swine was undertaken by the U. S. Department of Agriculture more than twenty years ago. Among the reports of the earlier investigators is one by Prof. James Law,† in which we find the lesions carefully described and a list of seventeen names under which the then supposedly single disease existed. Among these are hog cholera, enteric fever, gastro-enteritis, and others suggestive of the external manifestations of the disease such as erysipelas, measles and scarlatina, but none to indicate pneumonia or lung lesions of any kind. In consulting the earlier literature on swine diseases in England, we find practically the same nomenclature. The descriptions of the morbid anatomy are likewise very similar, and writers in both countries, but more especially Dr. Budd of England, have pointed out the similarity of this disease to typhoid fever in man. Up to the time of the investigations about to be mentioned, however, the opinion seems to have been that there was but one infectious disease peculiar to swine in America. In 1885 the investigators in the U. S. Bureau of Animal Industry discovered and described ‡ its specific organism. The disease was given the name

* Smith, Report of the Bureau of Animal Industry, U. S. Department of Agriculture, 1885, p. 196.

Ibid., 1895–96, p. 166.

Moore, The Journal Compar. Medicine and Vet. Archives, 1892, p. 333.

† Report of the U. S. Commissioner of Agriculture for 1875.

‡ First Annual Report of the Bureau of Animal Industry, U. S. Department of Agriculture, 1885, p. 212.

A summary of the results of the yearly investigations of the Bureau of Animal Industry may be found in the Annual Reports of the U. S. Department of Agriculture for 1884–1893.

swine plague and its organism was designated the bacterium of swine plague.

In the following year (1886) Dr. Theobald Smith * discovered another bacterial disease among swine. It was found to be similar to the German *Schweineseuche*, both in its morbid anatomy and in the morphology and properties of its specific organism. In naming this disease the Bureau of Animal Industry called it, on account of its similarity to the German *Schweineseuche*, swine plague, and its organism the bacillus of swine plague, and changed the name of the disease described in 1885 to hog cholera and its organism to the bacterium † of hog cholera. The changing of the name of the first disease described from swine plague to hog cholera has been the cause of some criticism and it has been credited with the responsibility of creating confusion. It has, perhaps, led hasty readers to a misinterpretation of these diseases and their relation to those described in other lands under different titles. While the names assigned may not have been especially happy ones, the transfer of swine plague from the intestinal to the lung disease must be considered as a fortunate occurrence and one which tended to simplify and not to confuse.

Dr. F. S. Billings, of the Nebraska State Experiment Station, opposed this classification. He not only refused to accept the change and continued to write about hog cholera under the title of swine plague, but he denied the existence of the swine plague, as described in the reports of the Bureau of Animal Industry for 1886 and subsequently, as an independent disease. The wide dissemination of his publications on this subject has unquestionably been responsible for much of the haziness concerning the distinguishing features of these diseases.

In 1893 Drs. Welch and Clements ‡ read a paper before the

* Second Annual Report of the Bureau of Animal Industry, 1886.

† In 1888 the genus *Bacterium* was changed to *Bacillus* and this organism is spoken of since that time as the hog-cholera bacillus.

‡ Welch and Clements, Remarks on Hog Cholera and Swine Plague, First International Congress of America held in Chicago, Ill., October, 1893.

International Veterinary Congress in which they gave a very clear history of the nomenclature of these diseases and in which they adhered to the classification of the Bureau of Animal Industry.

They also included in this paper the results of their investigations of numerous outbreaks of hog cholera, often complicated with swine plague, in the State of Maryland. The very few points in the pathology on which they differ from the conclusions of the Bureau will be referred to in later paragraphs.

In order that this part of the subject may be as clear as possible I have appended a partial list of the names assigned to those swine diseases which have been found to be identical with, or closely related to, the American hog cholera and swine plague. The results of the more important of the large number of special investigations which have been made in both the United States and in Europe to determine these facts have been largely brought together in the writings of Drs. Smith and Welch, who themselves have done most to elucidate our knowledge of these affections.

SYNONOMY.

Country.	Diseases.	
	Hog Cholera.	Swine Plague.
United States . . .	Hog Cholera[1]	Swine Plague[1]
" " . . .	Swine Plague[2]	
England	Swine Fever[3]	
"	Pneumo-enteritis[4]	
"	Pig Typhoid[5]	
Denmark and Sweden	Svinpest[6]	
" " "	Svinediphteritis[7]	
France	Pneumo Entérite du Porc	
"	Hog Cholera[8]	
Germany		Schweineseuche[9]

1. Salmon and Smith. Annual Reports of the Bureau of Animal Industry, 1885 and since that time.

Salmon. Special Report on Hog Cholera, its History, Nature and Treatment. *Ibid.*, 1889.

Smith. Special Report on the Cause and Prevention of Swine Plague. *Ibid.*, 1891.

Welch. Report of Investigations concerning the Causation of Hog Cholera. Johns Hopkins Bulletin, No. 1, 1889.

I am not familiar with authoritative statements of the existence of hog cholera or a like disease in Germany. The same is true of swine plague in France. The disease described by Cornil and Chantemesse as being identical with Schweineseuche was found not to be swine plague but probably hog cholera. With swine plague in Germany and hog cholera in France it is probable that both of these diseases may be found in each of these countries. Whether or not swine plague exists in England I will leave for her pathologists to answer.

CONCERNING THE MORBID ANATOMY OF HOG CHOLERA AND SWINE PLAGUE.

In the reports of the Bureau of Animal Industry hog cholera is described as occurring in two forms, acute and chronic. In the first the lesions are of a congestive or hæmorrhagic nature, while in the second they are characterized by distinctive tissue changes such as the "button" ulcers in the intestines, especially the cæcum and upper colon, enlarged and discolored spleen, enlarged and often hæmorrhagic lymphatic glands and usually hepatic and renal changes. Broncho-pneumonia is occasionally present. The chronic form is most frequently encountered.

Welch and Clements* look upon the formation of the "but-

* *Loc. cit.*

Smith. Zur Kenntniss der Amerikanischen Schweineseuche. Zeitschrift für Hygiene, 1891, S. 480.

Smith. Zur Kenntniss des Hogcholerabacillus. Centralblatt für Bakteriologie und Parasitenkunde, Bd. IX. (1891) S. 253.

2. Billings. Bulletins Neb. Agricultural Experiment Station 1888. Also many special publications and contributions to various veterinary journals.

3. Brown. Report of the Agricultural Department, London, 1886.

4. Klein. Seventh annual report, Local Government Board, London, 1877. Virchow's Archiv, 1884, Bd. XCV., S. 468.

5. Budd. Veterinarian, 1865, p. 521.

6. Selander. Centralblatt für Bacteriologie und Parasitenkunde, 1888, i. S. 362.

7. Lundgren. Ref. Jahresbericht de Veterinär-Medicin, 1889.

8. Metschnikoff. Annales de l'Institut Pasteur, VI., 1892, p. 289.

9. Loeffler. Arbeiten aus dem kaiserlichen Gesundheitsampten. Bd. I., (1885) S. 51.

Schütz. *Ibid.*, S. 376.

ton " ulcers as the most diagnostic of the lesions. These, of course, do not appear in the acute type where death occurs in a very short time, and consequently they cannot always be relied upon in making the diagnosis. During the last year we have seen the disease in its congestive or hæmorrhagic form, as described in the Bureau Reports, and the diagnosis was confirmed by obtaining pure cultures of the hog-cholera bacillus from the blood, liver and spleen. As pointed out by Smith, this form of the disease is rare. Welch and Clements mention it in cases produced by the intravenous inoculation of pure cultures, but it seems that they did not meet with it in more natural outbreaks. Space does not permit of a more extended account of the morbid anatomy as a wide range of lesions or modified forms is admitted. Suffice it to say, that the tissue changes found in a typical case of chronic hog cholera are quite analogous to those described in a similar case of typhoid fever in the human subject.

Swine plague is considered by Smith* to be an infectious pneumoenteritis as the intestines are frequently involved, but more often the lesions are restricted, for the greater part, to the lungs and pleura, and hence it is also called an infectious pneumonia. The morbid changes in the intestines usually consist, when present, of a superficial necrosis of the mucous membrane rather than distinct ulcers as in hog cholera. He describes it as an independent disease although frequently complicated with hog cholera. On this point there is some difference of opinion. Billings denies its existence excepting as a secondary infection. Welch and Clements * have not found outbreaks of pure or uncomplicated swine plague such as occur of *Schweinseuche* in Germany, but they have reported isolated cases and do not doubt the possibility of its occurrence in epizootic form. It was found by them, as it frequently appeared in Smith's investigations, complicated with hog cholera or with lesions which they believed to be due to the hog-cholera bacillus. The disentangling of the lesions of these two diseases has been difficult, perhaps

* *Loc. cit.*

the most so of any of the problems encountered in their investigation, and it will still be necessary to have the results of other and repeated observations before we can fully describe the range of morbid anatomy possible in either affection. Perhaps of the mooted questions the most important is in regard to the existence of swine plague in epizootic form.

Concerning swine plague as an independent disease the following, and heretofore unpublished observations, are of special interest. In the late fall of 1895 I had occasion to spend a few weeks with Dr. C. N. Hewitt, of the State Board of Health, studying an infectious swine disease in southern Minnesota. During this period we made careful post-mortems, and as thorough a bacteriological examination as it was possible under the circumstances, of one or more animals in each of twenty-nine herds. In many of these cases the lesions were largely restricted to the lungs, the digestive tract being normal. On the other hand, the ventral, cephalic and cephalic portion of the principal or caudal lobe of one, and usually of both lungs, were hepatized. As a rule there was no pleuritis. Pure cultures of the swine-plague organism were obtained, and rabbits inoculated with pieces of the hepatized lung from a few of the animals, died in from 16 to 48 hours of septicæmia, due to the swine-plague bacillus.

In a few cases the lesions varied from this form. Thus in one instance, a pig, of about thirty pounds weight, exhibited a slightly enlarged spleen, hæmorrhagic kidneys, and small areas of slight hyperæmia of the mucous membrane of the intestine. The tips of the ventral lobes of both lungs were collapsed. From the kidney, pure cultures of a very virulent swine-plague organism were obtained. Rabbits inoculated with a bit of the cortex of one of the kidneys died in 16 hours and from its organs pure cultures of swine-plague bacteria were secured. In a few herds, especially those near villages where the pigs were fed largely on kitchen refuse, there were a considerable variety of lesions from which *Bacillus coli communis* and other bacteria were isolated, but, so far as I was able to determine, the bacillus of

hog cholera was not present. In these cases the swine-plague bacillus was obtained.

The disease in these herds invariably ran a rapidly fatal course, and in many herds over ninety per cent. of the hogs died. The most pronounced symptom observed was a severe cough which was brought on if the sick animals were forced to run. This, with the refusal of food, were the only ones reported by the owners. The origin of the disease had been traced by several local health officers to a drove of swine which had been brought into the locality and sold. While these observations cannot be considered as conclusive evidence of the singleness of the disease, as a careful bacteriological examination was not made of all of the animals which died in a single outbreak, the occurrence of uncomplicated pneumonia in animals in various stages of the disease in the different herds is highly suggestive that the disease was pure swine plague in epizootic form.

During the past year I have examined several animals from a number of outbreaks of infectious swine disease in the State of New York. In two of these outbreaks the lesions found in the pigs examined were pneumonia with and without pleuritis. The spleens were usually enlarged. The intestines were not affected. The bacteriological examination revealed the presence of swine-plague bacteria, but hog-cholera bacilli were not found. In a few outbreaks there were mixed infections such as described by Smith, and later by Welch and Clements.

These investigations support the conclusions of Dr. Smith that swine plague is an independent disease although it often exists associated with hog cholera. An explanation for the frequency of the latter condition will be suggested in a later paragraph.

To summarize, the differentiation of these diseases by their morbid anatomy is, in typical cases, not difficult. In hog cholera there are ulcers in the intestines with enlarged and often hæmorrhagic lymphatic gland, engorged and darkened spleen, and usually changes in the kidney and liver. In swine plague there is more or less hepatization of one or both lungs with or with-

out pleuritis. There may be slight morbid changes in the abdominal organs. In the atypical cases, which the reports show are very numerous, there may be marked variations in the nature of the lesions. In fact, the course of either disease may become so changed that its nature cannot be determined at the post-mortem. In these, and in very acute cases where either disease may become a septicæmia, the macroscopic examination must be supplemented by the results of a bacteriological investigation before a positive diagnosis is warranted. The only final test of the nature of the disease is the character of the bacteria responsible for it.

THE BACTERIA OF HOG CHOLERA AND SWINE PLAGUE.

The various accounts of the specific bacteria of hog cholera and swine plague have led to more confusion than those relating to their morbid anatomy. These bacteria have been fully and clearly described in the reports of the Bureau of Animal Industry and in certain other publications. In addition to the original descriptions, the differences between these two species have been pointed out repeatedly by pathologists in other countries, especially in Germany. Notwithstanding, errors have appeared either through accident or misinterpretation. Thus, Schoug * decided from his bacteriological investigations that hog cholera, swine plague and Schweineseuche were identical. Selander † and Metschnikoff ‡ published some startling results from investigations with the bacillus of hog cholera and which they stated was identical with the bacillus of American hog cholera (Salmon). Their experiments were carefully repeated in the Bureau of Animal Industry with conflicting results. Those of Selander were also repeated by Prof. Welch with a similar outcome. Upon examination of the organism with which they worked, a

* Ref. Jahresbericht der Veterinar-Medicin, 1889.

† Annales de l'Institut Pasteur, IV. (1890), p. 543.

A report of the experiments made to verify Selander's statements in this article are given in Bulletin No. 6, Bureau of Animal Industry, 1894, p. 97.

‡ *Loc. cit.*

culture of which was kindly sent to Dr. Salmon by Metschnikoff, it was found to be the bacillus of swine plague. The results which they had reported were not strikingly different from those which we have obtained under certain conditions, with the swine-plague organism. To understand their results, in the light of those obtained in this country, it is necessary to read swine plague where they have written hog cholera. By doing this, the confusion which otherwise will be caused by their articles on the hog-cholera bacillus will be avoided.

In the last edition of his Text Book of Bacteriology and Infective Diseases, 1897, Crookshank writes that, "the bacillus isolated by Loeffler and Schütz from swine fever in Germany (*Schweineseuche*) has been identified with the bacillus isolated by Salmon and Smith from hog cholera in America, and with the bacillus of rabbit septicæmia and of fowl cholera." Such statements are certainly confusing.

Again we find the influence of Billings' interpretations, published long after the bacteria in question were described, in which he states that the bacillus of swine plague* is actively motile. During the past year I have received statements from two distinguished bacteriologists of the existence of motile swine-plague bacilli. This is important, for it shows an unmistakable error somewhere. If we have been in the wrong concerning the motility of this organism, we are ready upon sufficient evidence to retract, but thus far we have not observed either independent movement or the organs of locomotion (flagella) on this species of bacteria. It is not surprising, however, that after the appearance of so much literature in which the swine-plague bacillus has been assigned the morphology and properties of the bacillus of hog cholera that confusion should arise.

In comparing these two species of bacteria it is necessary for our purpose to call attention simply to their more essential properties which may be considered of differential value. In order that these may be more easily contrasted I have arranged them in like order in parallel columns.

* He is writing of the disease known to the Bureau of Animal Industry as hog cholera.

Bacillus of hog cholera.

1. Rod-shaped organism with ends rounded, 1.2 to 2.0μ in length, 0.5 to 0.8μ in width. The size varies according to the stage of growth and division, and the culture media.

2. From cultures it stains entirely. In tissues it usually stains around the periphery with darker extremities leaving a light centre.

3. Actively motile in liquids.

4. From 3 to 9 flagella are demonstrable.

5. Vigorous growth in alkaline nutrient liquids. Less vigorous if liquids are acid in reaction.

6. Moderate growth on potato. (Varies according to reaction.)

7. Distinct growth on gelatin.

8. Saponifies milk in from 3 to 4 weeks.

9. Ferments dextrose with the formation of acids and gas.

10. Does not ferment lactose. Bouillon containing it becomes strongly alkaline. No gas.

11. Does not ferment saccharose. Bouillon containing it becomes strongly alkaline. No gas.

12. Destroyed by moist heat at 58° C. in 15 minutes.

13. Dies in water in from 2 to 4 months.

14. It dies in the soil in from 2 to 3 months.

15. Rabbits injected subcutaneously with 0.1 c.c. of a bouillon culture of a virulent bacillus will die in from 5 to 7 days. Enlarged spleen, necrotic foci in liver.

16. Rabbits inoculated with culture of an attenuated variety live from 10 to 20 days or recover. The lesions are enlarged spleen, and infiltration of the follicles in Peyer's patches.

17. In guinea-pigs the lesions are practically the same as in rabbits. Death occurs in from 7 to 12 days.

Bacillus of swine plague.

1. Elongated oval organism 0.8 to 1.5μ in length, 0.6 to 0.8μ in thickness. The size varies according to the stage of growth and division, and the culture media.

2. From old cultures it usually stains entirely. When in process of division as found in the organs of freshly dead rabbits the extremities stain leaving an unstained central band, "polar stain."

3. Not motile in liquids.

4. No flagella have been found.

5. Growth moderate or feeble in alkaline nutrient liquids. No growth if liquids are acid.

6. No growth on potato.

7. Feeble or no growth on gelatin.

8. Produces no apparent change in milk.

9. Ferments dextrose with the formation of acids but no gas.

10. Does not ferment lactose. No gas.

11. Ferments saccharose with the formation of acids. No gas.

12. Destroyed by moist heat at 58° C. in 7 minutes.

13. Dies in water in from 10 to 15 days.

14. It dies in the soil in from 4 to 6 days.

15. Rabbits injected subcutaneously with 0.01 c.c. of a bouillon culture of a virulent bacillus will die in from 16 to 20 hours. Septicæmia.

16. Rabbits inoculated with a culture of an attenuated variety will live from 4 to 10 days. The lesions are local infiltration of pus cells with pleuritis, pericarditis or peritonitis.

17. Guinea-pigs are slightly less susceptible than rabbits. There is more local reaction. Death occurs in from 1 to 4 days.

18. Pigs are not usually affected by subcutaneous injection of small quantities of culture. If the pigs are killed within 1 to 3 weeks the bacilli are found in the local lesion and certain of the lymphatic glands.* Fatal results are reported in a few cases by these injections.	18. Pigs are not usually affected by the subcutaneous injection of small quantities of culture. The bacilli are not found except in the local lesion. In a few cases fatal results are reported
19. Feeding cultures to pigs which have fasted for 24 hours produces extensive intestinal lesions with fatal results.	19. Feeding cultures to pigs usually produces no effect.
20. Intravenous inoculation into pigs causes either an acute septicæmia or a chronic form of the disease in which are produced quite typical round, firm, elevated ulcers.	20. Intravenous inoculation into pigs usually produces a septic form of the disease which kills in from 1 to 2 days. Inoculation into the lungs causes pleuritis, usually accompanied with pneumonia.

* Moore, What becomes of hog-cholera and swine-plague bacteria when injected subcutaneously in small quantities in pigs. Bulletin No. 6, Bureau of Animal Industry, 1894, p. 101.

The results of inoculation experiments with these bacteria are conclusive in establishing their causal relations to their respective diseases. In explaining the differences in results reported by different investigators the method, age, and kind of culture and the degree of virulence of the bacteria used, together with the age and condition of the swine inoculated, must be taken into consideration.

Several varieties of the hog-cholera bacillus have been recognized. As early as 1890 Smith * called attention to a variety of this organism which was more saprophytic in its tendencies than the form usually encountered. In 1894 he described seven varieties † of the hog-cholera bacillus which had been isolated from swine. These varieties differ either morphologically, in the character of their growth on ordinary media, in the quantity of gas produced in glucose bouillon or in their pathogenesis for rabbits. In addition to these, Smith places the bacillus found by him in aborting mares,‡ *Bacillus enteritidis* of Gaertner and *Bacillus typhi murium* of Loeffler in this group.

*New York Medical Journal, Nov. 1, 1890, p. 485.

† These are designated as *B. choleræ suis* $\alpha,\beta,\gamma,\delta,\varepsilon,\zeta,\eta$. The hog-cholera group of bacteria. Bulletin No. 6, Bureau of Animal Industry, 1894.

‡ Bulletin No. 3, Bureau of Animal Industry, 1893.

Through the kindness of Dr. D. E. Salmon, I received, about two years ago, from Prof. Mereshkowsky,* of St. Petersburg, a culture of the bacillus which he found to produce a fatal disease in ground squirrels. A careful study of this organism shows that it belongs to the hog-cholera group, and at present I am studying a culture of the hog-cholera bacillus which appears to differ slightly from all those heretofore mentioned. Without entering into a discussion of the varieties of this species, suffice it to say that *B. choleræ suis α*, as described by Smith, stands, by virtue of the priority of its discovery, as the type. There are closely related to this a considerable number of important bacteria, some of which have been described under quite different names. Although some of them have been found to approach in their biochemic properties *B. coli communis* the bacillus of hog cholera stands as a clearly defined and distinct species of pathogenic bacteria.

The bacillus of swine plague and its varieties have not been so systematically classified. It is of interest to note, however, that the bacilli of rabbit septicæmia, fowl cholera and of certain diseases of cattle are thought to be identical with it. They have not been differentiated in their morphology or cultures. In grouping these bacteria the fact should be recognized that experimentally these bacteria are not interchangeable in their pathogenesis except for the rabbit. Thus an epizootic form of fowl cholera has not been produced with the swine plague or rabbit septicæmia bacilli. Further, it has been shown † that in the upper air passages of healthy swine, cattle, horses, cats and dogs there are bacteria not distinguishable in their cultural characters and their effect upon rabbits from the swine-

* Centralblatt für Bakteriologie und Parasitenkunde, XVII. (1895.) S. 742.

† Smith. Special report on swine plague, 1891, p. 109.

Moore. Appendix special report on swine plague, 1891, also Bulletin No. 3, Bureau of Animal Industry, U. S. Department of Agriculture, 1893, p. 38.

Fiocca. Centralbl. f. Bakteriol. u. Parasitenk. Bd. XI., S. 406.

The investigations thus far made show these bacteria to be present in 48 per cent. of healthy swine, 80 per cent. of cattle, 50 per cent. of sheep, 16 per cent. of horses, 90 per cent. of cats, and 30 per cent. of dogs.

plague bacillus. The presence of this organism in the trachea of healthy pigs has been suggested as the cause of sporadic cases of swine plague and it may explain the frequent association of swine plague with hog cholera. What the conditions are by which these bacteria are enabled to produce disease in their host have not been clearly pointed out. The pathogenic organism associated with the lesions in certain forms of bronchopneumonia in cattle differs very slightly from this. In human pathology we find a striking resemblance in *Micrococcus lanceolatus* * to the swine-plague bacillus. While there are differences between the behavior of this organism and the swine-plague bacillus, its manifold and varied pathogenic possibilities and its distribution in normal human saliva are worthy of notice in this connection.

If we take the rabbit as the animal on which to test the pathogenesis of the bacteria belonging to the swine-plague group we find that those from different sources are very similar. In nature, the bacilli of swine plague, rabbit septicæmia, fowl cholera, and those located in the normal upper air passages of the various species of animals mentioned exist possessed of marked variation in virulence, that is, those which will kill a rabbit when inoculated subcutaneously with pure culture in from 16 to 24 hours to those which require from 3 to 10 days to destroy life. With the variations in the length of time we have corresponding differences in the lesions. Thus the virulent forms produce septicæmia while the attenuated varieties excite a severe purulent infiltration about the place of inoculation and exudates on one or more of the serous membranes. Conversely, it has been shown that rabbits possessed of a certain amount of natural or artificially produced resistance will, when inoculated with a virulent culture, die after the same period of time and with lesions similar to those produced by the attenuated virus in the susceptible rabbit, or, if the resistance approaches in degree to immunity the lesions may be restricted to single or multiple abscesses which develop slowly in

* Welch, Bulletin Johns Hopkins Hospital, III., 1892, p. 125.

various parts of the body. In hog cholera the course of the disease may also be changed. In rabbits the lesions become localized in the digestive tract, and in guinea-pigs there is a formation of nodules, usually beneath the peritoneum, resembling somewhat closely in appearance miliary tubercles. This relation between the degrees of virulence of the bacteria on the one hand and the relative resistance of the animal body on the other has been expressed * by the simple formula $d=\frac{v}{r}$ in which d= the type of the disease, v= the virulence of the bacteria, and r= the resistance or degree of immunity of the animal used. By changing either virulence or resistance the type is changed.

A careful study of the details of the methods by which the course of these diseases may be modified shows that there is a marked difference between hog cholera and swine plague in the ease with which they are diverted from their more usual manifestations. Again, when they are studied in their most varied and extreme modifications we find that they differ quite as much as do the lesions produced by the virulent bacteria in susceptible animals. In both affections the modified forms tend to the production of a type of disease simulating that in the larger, more resistant species of animals, such as swine.

Another, and I believe important differential feature, is found in the behavior of experimental animals to immunizing treatment. With hog cholera, rabbits have not been immunized excepting with attenuated living cultures, and then with much difficulty. On the other hand, guinea-pigs are immunized by means of injections of sterilized cultures, sterilized blood of affected animals or the serum from immune animals. With swine plague, both rabbits and guinea-pigs can be made resistant to the strong virus by these methods. The very marked difference in the effect on rabbits of the immunizing agents of the two diseases is noteworthy. Again and still more significant is the fact that guinea-pigs made immune to hog cholera offer no resistance to virulent swine-plague bacteria and *vice versa*.

* Smith and Moore, Bulletin No. 6, Bureau of Animal Industry, 1894, p. 89.

If time permitted it would be interesting to analyse the arguments which have been advanced to prove the identity of these affections. It would be equally instructive to discuss the various experiences in reference to certain properties of these bacteria, such for example, as the formation of indol, their reaction to the Widal serum test, and their toxins and antitoxins. These, however, are still in the experimental stage. It should be stated, that while it may be possible, under certain restricted conditions, to point out more similarities than differences, I have failed in my task if I have not shown that from first to last these diseases are different. When their investigation is extended by any of the methods of modern bacteriological or pathological research we are impressed with their striking dissimilarities, rather than with their exceptional resemblances. Thus, in the study of their morbid anatomy, the morphology and biochemic properties of their specific organisms, or in the mysterious problems of artificial immunity and resistance, they differ the one from the other. Finally, as I understand them, the diseases known in America as hog cholera and swine plague are separate and independent affectious, and each should have an unchallenged place in the annals of comparative medicine and pathology.

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SUPPURATIVE CELLULITIS IN THE LIMBS OF CATTLE DUE TO STREPTOCOCCUS INFECTION.

By Veranus A. Moore, M. D.

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In August, 1897, my attention was called to an interesting disease affecting the feet and lower limbs of cattle in certain parts of Herkimer County. The affection had received the local designation of "foot rot," and, on account of its apparent contagiousness, it was viewed with much apprehension by the cattle owners of that vicinity. It was found, however, that it had not spread over a very large territory, but that several dairy herds had suffered quite severely. Unfortunately, it was not reported to us until the height of the trouble had passed, so that this article is based upon the examination of a few animals suffering from the naturally-contracted disease and upon the cases experimentally produced.

The manifestations of the disease were, within certain limits, uniform in all of the affected animals. Usually but one foot or leg was attacked, although there were numerous exceptions. The first symptom noticed was a swelling, which usually appeared in the lower part of the leg, most often in the pastern. In some animals it was said that the swelling was restricted to a small area, but often it extended up the leg to and even above the knee or the hock joint. There was evidence of pain and the animal became very lame. As the inflammatory process continued, the subcutaneous tissue became indurated, the skin thick and dry and eventually it would crack, usually, but not always, below the dew claws, and a thick creamy pus would be discharged. After discharging, the swelling subsided and the normal condition was rapidly restored. The extent of the swelling and the time necessary for the suppurative process and recovery varied in different animals, but as a rule from ten to fifteen days were required. The exceptions were largely in those cases where the inflammatory process extended down to

the coronary cushion. In these there was more or less sloughing of the hoof, and it was in these cases that the disease appeared in its most serious form. So far as I learned all of the animals eventually recovered. A personal examination was made of five cases, which were in two herds on adjoining farms.

Case No. 1. A cow, 7 to 8 years old. The trouble was in the right hind foot. She had recovered from a severe attack in the right fore foot. There was still some swelling in the hind leg and the skin and subcutaneous tissue above the heel were much thickened. There were two cracks below the dew claws, from which, the owner of the animal said, there had been a profuse discharge. At this time pus could not be obtained. Several small pieces of the infiltrated tissue were secured. From some of these agar tubes were inoculated at the time and the others were placed in sterile tubes and brought to the laboratory for further examination.

Case No. 2. This was in a cow, about six years old, in the same dairy. The left fore leg was just beginning to swell. There was evidence of pain and the skin from the hoof to the knee was sensitive to the touch. The temperature was normal, but there was indifference to food. This case was treated locally by Dr. Law, with recovery without suppuration.

Case No. 3. (Cases 3 to 5 were in the second herd.) This was in a cow, seven years old. The right hind leg was affected. The disease had already run about three weeks and for several days the animal had been under the care of a veterinarian. The cellulitis had extended up the leg to and above the hock joint and down to and over the coronary cushion. The hoof covering the heel had cracked and part of it had been removed. There was a large subcutaneous abscess above the heel, which was discharging through an opening or crack in the hoof near the middle of the bottom of the foot. It was stated that at first the pus was thick and of a cream color, but at this time it was thin and of a dirty brown tint. By means of pressure a considerable quantity of it was forced out, from which tubes of agar were inoculated and a few cubic centimeters placed in a sterile tube and brought to the laboratory.

Case No. 4. This was in a two-year-old heifer. The left hind foot was attacked. The leg was slightly swollen. There was distinct fluctuation over an area about 3 cm. in diameter, on the front of the foot and just above the hoof. The animal seemed to be well otherwise. Temperature normal and appetite good. The hair was clipped, the foot carefully washed and disinfected and the abscess opened. It contained about 5 c.c. of a thick creamy looking pus. Several tubes of agar were inoculated from this and the balance placed in sterile tubes for further examination.

Case No. 5. This was in a two-year-old heifer. The left hind foot had been affected, but at this time it had discharged, the swelling had subsided, and the abscess was practically healed.

The disease in Cases Nos. 3 and 4 seemed to resemble Panaritium,* the essential difference being in the extent of the inflammatory process. Until the specific cause of that affection is more definitely determined, and the extent of the lesions included within the possibilities of its etiological factor more clearly defined, the question of its identity or non-identity with the local infections here described cannot be answered. In both the disease seems to be due to local causes.

Bacteriological Examination.—As already stated, several agar cultures were made at the time of the examinations from the pus or indurated tissue from three of the cases. On the following day bouillon and agar tubes were inoculated and gelatin and agar plate cultures were made. In addition to these several cultures were made on special media from the material obtained in sterile tubes. Without entering into wearisome details, the results of these cultivations from the different animals may be summarized as follows:

From Case No. 1.—A streptococcus and an undetermined micrococcus and bacillus.

From Case No. 3.—A streptococcus and several (about six) forms of chromogenic micrococci and bacilli. (The foot in this case had been wrapped for several days in oakum wet with some disinfectant.)

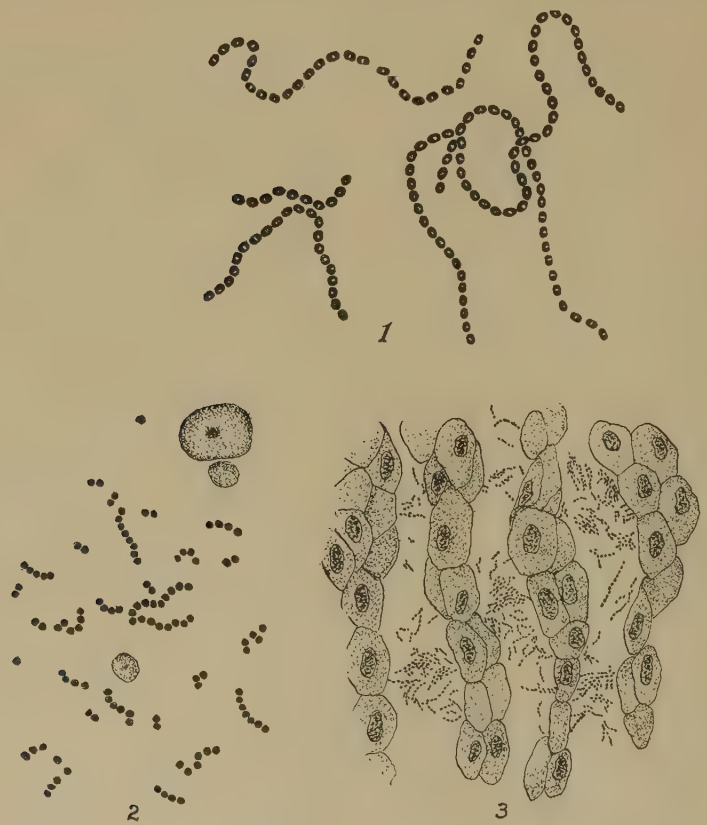
From Case No. 4.—A streptococcus which appeared in pure culture in most of the tubes. In three tubes *bacillus coli communis* was also present.

In the plate cultures in agar made from the material from cases Nos. 1 and 4 colonies of the streptococcus predominated. In those prepared from case No. 3 colonies of chromogenic micrococci were more numerous.

The culture of the colon bacillus was carefully studied in both its cultural characters and its effect upon animals, but it did not reveal any properties uncommon to that species. This,

* Möller. Speciellen Chirurgie, S. 849.

together with the fact that it appeared in the cultures from but one case, suggests that its presence was accidental and that it did not stand in any etiological relation to the inflammatory process. With the exception of the streptococcus, all of the other bacteria which appeared in the culture were common saprophytes which presumably had found their way into the open sores.



Description of Plate.

Fig. 1. A drawing of streptococci made from a cover-glass preparation from a fresh bouillon culture stained with alkaline methylene blue. Magnified about 1500 diameters.

Fig. 2. A drawing from a cover-glass preparation from the liver of a rabbit dead from inoculation with the streptococcus stained with alkaline methylene blue. Magnified about 1000 diameters.

Fig. 3. A drawing from a section of the liver of a rabbit dead from the inoculation with the streptococcus. (Same rabbit from which drawing Fig. 2 was made.) Sections cut by the paraffin method and stained with carbol fuchsin. It shows the *blood spaces* to contain a large number of streptococci. Magnified about 500 diameters.

The microscopic examination of cover-glass preparations from the pus taken from case No. 4 showed a streptococcus in short and long chains. In those made from the material from cases Nos. 1 and 3 there were in addition to the streptococcus several other forms of bacteria. The infiltrated subcutaneous tissue from case No. 1 was found to consist of round cell infiltration. The fresh preparations of the pus from the other cases (Nos. 3 and 4) revealed nothing unusual for purulent material.

Inoculation into Cattle.—In order to determine the infectious nature of the trouble, two cows were inoculated with the material obtained from cases Nos. 3 and 4. A small portion of the pus from each specimen was diluted in sterile bouillon and about 2 c.c. of the suspension injected subcutaneously just above the hoof in the left fore foot in each case. Swelling was noticed on the third day. It gradually extended up the leg to the knee joint. There was much tenderness and evidence of pain. The subcutis became indurated in the lower part of the leg and on the 10th and 12th days suppuration was evident. The abscesses were not opened, but a few days later they broke just under the dew-claws, near the place of inoculation, and discharged a considerable quantity of cream-colored pus, after which complete recovery soon followed. The streptococcus was obtained in pure culture from each of these cases.

A third cow was inoculated with a pure bouillon culture 24 hours old of the streptococcus obtained from case No. 4. The inoculation was made by scraping the skin on the right fore foot just above the hoof, and after removing the epidermis the culture was rubbed on the raw surface. Swelling began in three days and the symptoms already described followed in regular order. A subcutaneous abscess formed and on the 14th day it discharged. The streptococcus was obtained in pure cultures from the freshly discharged abscess. Recovery rapidly followed.

A cow was inoculated in the tail with a pure culture of the streptococcus with negative results.

The Streptococcus.—The cultures of streptococcus isolated from the different animals (cases Nos. 1, 3 and 4) were carefully compared in parallel cultures and found, so far as this method enabled one to determine, to be identical. The organism was a true streptococcus. Morphologically it grew in long chains in bouillon and agar. It stained readily with aniline dyes, but it did not retain all of its color when treated after Gram's method. Each coccus or segment seemed to be distinct. Many of them gave a decided polar stain, although this was not uniformly the case. In sections of the liver of inoculated rabbits it appeared in the blood spaces in large numbers and in long chains, but in cover-glass preparations they seemed to be quite broken up into shorter chains, diplococci and single micrococci.

In bouillon it grew in clumps or grayish masses, which settled to the bottom or sides of the tube if they were inclined. After several generations a more uniform cloudiness was imparted to the bouillon. Milk was not changed in appearance.

On agar the isolated colonies were about 1.5 mm. in diameter with a convex brownish centre surrounded by a thin spreading growth. It did not grow on potato and very feebly on gelatin. In alkaline bouillon containing 1 per cent. of the sugars ordinarily used (dextrose, saccharose and lactose) the reaction became strongly acid, but gas was not formed.* The streptococci were soon destroyed in the acids formed in these cultures. In the fermentation tube the growth was quite vigorous in the open bulb, but exceedingly feeble in the closed branch.

This organism was very sensitive to the action of disinfectants and it possessed a low thermal death point, an exposure to moist heat at a temperature of 55° C. for 5 minutes destroyed it. (These tests were not repeated.)

In rabbits it produced a rapidly fatal septicæmia, destroying life in from 36 to 48 hours. Guinea-pigs were not affected un-

* In this respect it conforms with the action of all the streptococci with which I am familiar. This power of the streptococci to break up the sugars forming acids without gas seems to be of value in differentiating doubtful streptococci from certain micrococci which often appear in short or longer chains.

less large doses were injected into the peritoneal cavity. Unfortunately, this streptococcus stopped growing very suddenly before I had extended its study sufficiently to positively identify it, and before the first results with disinfectants and the thermal death point had been verified. It agrees very closely with the description of *streptococcus pyogenes bovis Lucet* * with the exception that it is more virulent for experimental animals. This, however, cannot be considered of very much importance. Further, I have not been able to find distinctive characters or properties to differentiate it from *streptococcus pyogenes.* Additional investigations will be necessary to show that the streptococci producing suppuration in cattle and in man are separated by specific or veriatal differences.

Source of Infection.—Although this disease appeared to be of much importance in its beginning its early disappearance quieted the fear that the locality was invaded with a "contagious foot rot" and attention was directed to an inquiry into the source and manner of infection. Concerning this positive information was not secured. However, a few important conditions affecting the immediate environment of the animals were found to have been so closely associated with the trouble that they are quite suggestive. The cattle in the herds where the disease appeared were driven a considerable distance morning and evening through paths which were very muddy. As would be expected, the mud was heavily laden with fecal and decomposing vegetable matter. It was thickly sprinkled with stone of a flat, sharp, angular variety. It is presumable that the animals in wading through these places scratched their feet or legs slightly but enough to cause the infection of the organism which it is assumed was in the top soil. It was a noteworthy observation that the disease begun with a "rainy spell," and consequently muddy paths and yards, and disappeared after the mud dried up. Previous investigations† have shown that delicate streptococci are sometimes present in the soil. The numerous recorded observations on this group of bacteria show that

* Annales de L'Institut Pasteur, VII (1893), p. 324.

† Bulletins No. 3 Bureau of Animal Industry, U. S. Department of Agriculture, 1893.

streptococci are not only widely distributed in nature, but also that they are frequently associated apparently as the etiological factor in various morbid processes. Their presence in inflammatory lesions leading to suppuration is quite noticeable.

The number of bacteria which have been found associated with suppuration in the bovine species is already quite large, but as yet streptococci seem to be the organisms most frequently encountered. Lucet (l. c.) has reported 52 cases of abscess in cattle which were examined bacteriologically. A list of the organisms isolated from these cases is appended.

Streptococcus pyogenes bovis. . . . . in 9 cases.
Staphylococcus pyogenes bovis . . . . . in 2 cases.
Bacillus pyogenes bovis. . . . . in 6 cases.
Bacillus liquefaciens pyogenes bovis . . . . . in 4 cases.
Bacillus crassus pyogenes bovis . . . . . in 1 case.
Streptococcus and staphylococcus . . . . . in 3 cases.
Streptococcus and B. pyogenes . . . . . in 4 cases.
Streptococcus and B. crassus . . . . . in 2 cases.
Streptococcus, staphylococcus and B. crassus. . . . in 1 case.
Bacillus pyogenes and bacillus crassus . . . . . in 1 case.
Bacillus pyogenes and bacillus liquefaciens. . . . . in 2 cases.
One or the other of the above mentioned organisms
with an undetermined species . . . . . in 14 cases.
with staphylococcus pyogenes albus of man . . in 1 case.
with staphylococcus pyogenes aureus of man. . in 2 cases.

It seems from the present knowledge concerning the causes of suppuration in cattle that the importance of streptococci can not be questioned. This is of interest, as cattle are not especially susceptible to bacterial infection nor are the streptococci the most hardy of pyogenic organisms. It remains for future investigations to determine whether the various streptococci found in these lesions belong to a single species and if so to find in what respects it differs from *streptococcus pyogenes*. Unfortunately, Lucet does not point out the distinguishing features which led him to separate the pyogenic organisms found in cattle from those which had already been described from similar lesions in other animals and in man.

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Thermo-regulated Waterbaths for the Bacteriological Laboratory.

Page 108

There is, perhaps, a no more useful piece of apparatus in a general bacteriological laboratory than a suitable thermo-regulated water bath. The uses to which it may be advantageously put are so numerous that after the habit of using it is established it soon becomes almost indispensable. Wiesnegg anticipated its value and placed upon the market his bain-marie which has met with unquestioned favor. However, its usefulness, on account of its form and size, is somewhat restricted. In order to extend the utility of the principle involved in this apparatus, I have had, by way of experiment, two water baths or tanks constructed and permanently fitted with thermostats and thermometers. They have been in use for nearly a year and have proven to be so satisfactory that a brief note concerning them may be of general interest. Their shape or size should not be taken into serious consideration, for they are flexible features which can easily be adapted to individual needs or requirements. The emphasis should be placed rather on the assistance they render in the saving of time and in the securing of uniform results. In laboratories where instruction is given such assistance is much appreciated by both students and instructors.

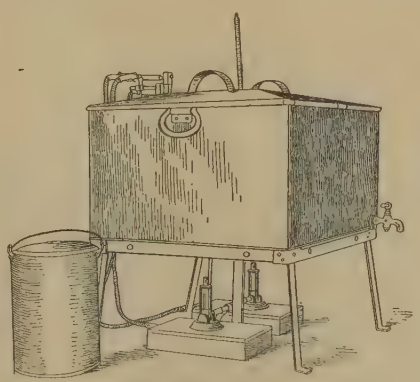

Fig. 1.

The larger water bath (Fig. 1) to which a thermostat was connected is of special value in macerating meat at a high (60-65° C.) temperature for making culture media. It can also be used for a variety of other purposes, such, for example, as sterilizing liquid blood serum or by a class of laboratory students in determining the approximate thermal death points of different bacteria. It consists of a rectangular copper tank 45x50x25 centimeters. It is divided

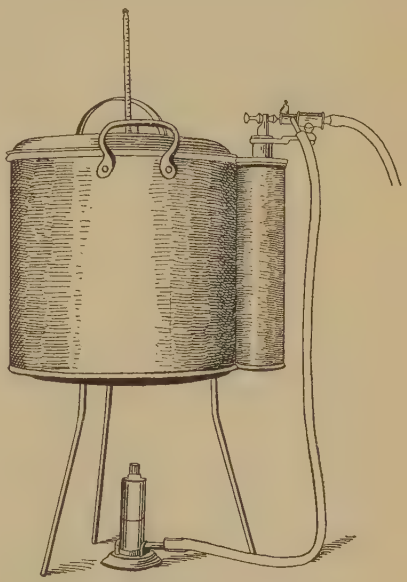

Fig. 2.

into two apartments, each of which has a separate cover and perforated false bottom. The partition consists simply of a top crosspiece which is about four centimeters wide. Near its center is a round opening two centimeters in diameter for a thermometer, which is protected by a perforated copper tube extending to and soldered to the bottom of the tank. Near the end of the crosspiece, or close to the side of the tank, there is a second and similar opening and shield for a thermostat. There is a faucet for drawing off the water. The tank stands on an iron quadruped. For heating it has been found desirable to use two burners, one under the middle of each side or apartment, the burners being connected by means of a T or Y tube to the gas tube leading from the regulator.

The smaller water bath (Fig. 2) was made for the use of individual (research) students. It is cylindrical in form,

Pag

twenty-five centimeters high and of about the same diameter. On one side there is a semicircular projection forming a chamber for the thermostat. This is separated from the main tank by means of several narrow strips of copper soldered at each side. The tank is provided, like the larger one, with a perforated false bottom. The cover has an opening for a thermometer. An apparatus of this size makes an admirable milk pasteurizer. It is not expensive and when properly set up requires comparatively little time to operate it.

The Friedberg burner has been found to be very satisfactory for these baths, as they possess to an unusual degree, when properly adjusted, the desirable quality of maintaining a very small flame without striking back. The Roux thermostat seems to be the best regulator for this particular purpose. It is constructed out of metal and consequently it is not easily broken. It is readily adjusted and quite as sensitive as the ordinary spirit or mercury thermo-regulators.

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A Report Concerning the Nature of Infectious Swine Diseases in the State of New York, with Practical Suggestions for their Prevention and Treatment.

By Veranus A. Moore, B. S., M. D.,

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In the State of New York, as elsewhere in this country, the infectious swine diseases which are of the greatest economic importance are hog cholera and swine plague. A third infectious disease peculiar to this species known as swine erysipelas in England, *rouget* in France and *Rothlauf* in Germany has not become prevalent in this country, although its probable appearance in one of the western States has been announced.

In addition to the above, swine are subject to several diseases common to other animals and to man. Outbreaks of anthrax occasionally occur in which many animals perish. Tuberculosis is not infrequently found in pigs fed upon the milk or offal of tuberculous cattle. Hogs are sometimes bitten by rabid dogs and die of rabies. There are also several animal parasites which infest swine; some of these produce serious losses, while others, like trichinae render their hosts dangerous for human consumption. It has further been observed that swine are susceptible to smallpox and diphtheria but cases of these are of very rare occurrence. Many hogs die from the effect of improper care but these fatalities are generally heralded as being due to some one or other of the infectious or contagious diseases. These various affections

are of much importance and every precaution should be taken to prevent them, and all known means employed to eradicate them, if they should appear. The scope of this report, however, will not permit of their further discussion and we pass at once to the consideration of the two diseases first mentioned and to those disorders brought about by unsanitary surroundings and unwholesome food.

Although hog cholera and swine plague have been carefully described in the official reports of the Bureau of Animal Industry, United States Department of Agriculture, and the distinctive characters of each have repeatedly been pointed out in various other publications, the investigation of the last year has shown that there are many farmers who are not sufficiently familiar with the nature of these maladies to properly guard their herds against them. As swine diseases are among those of the highest economic importance, as measured by the market value of the animals they destroy, it is fitting that they should again receive special attention. For the convenience of the reader, it has seemed best to divide the subject matter of this report into four parts as follows:

I. A somewhat popular discussion of hog cholera and swine plague, based upon the facts taken largely from descriptions already published and which are familiar to investigators in this line. This part is intended primarily for those who are not already familiar with the nature of these diseases.

II. A test of the swine plague "antitoxin" or serum prepared by the United States Bureau of Animal Industry for the treatment of swine plague.

III. A report of the investigations which have been made during the past year into the nature of the outbreaks of infectious diseases among swine in this State.

IV. A description of the bacilli of hog cholera and swine plague based upon the study of these organisms obtained from the epizoötics in this State.

I.

HOG CHOLERA.

Historical sketch.— The earliest outbreak in this country of which we have knowledge of a disease supposed to be hog cholera occurred in the State of Ohio in 1833. It is presumed that it was brought from Europe with some of the animals imported from there to improve the American breed of swine. After being introduced, it spread at first slowly, but later with increasing rapidity along the lines of commerce, until it has invaded every part of this county where swine raising has become an industry. It has been shown by investigators in England, on the continent of Europe, and in the United States Bureau of Animal Industry, that the swine fever of Great Britain and the swine pest of Denmark, are identical with American hog cholera.

In 1875, Prof. James Law* published a paper on his investigations of hog cholera or "intestinal fever in swine," in which we find the lesions carefully described and the following list of names under which the disease was then known, viz.: typhoid fever, enteric fever, typhus carbuncular fever, carbuncular gastro-enteritis, carbuncular typhus, pig distemper, blue sickness, blue disease, purples, red soldier, anthrax fever, scarlatina, measles, diphtheria and erysipelas. Some of these names are still used. Recently my attention was called to a popular work on swine diseases in which many of these terms are employed. They are of popular origin and seem to refer to some one or more of the observed symptons. The fact should not be overlooked that formerly all of the apparently infectious diseases of swine were generally thought to be identical. Unfortunately, in many places, this opinion seems to be still entertained.

In 1885, the bacillus, or causal agent, of this disease was discovered and described by the workers in the United States Bureau of Animal Industry.†

This important discovery swept away many of the existing theories concerning the nature of hog cholera. It established the

* Report of the United States Commissioner of Agriculture, 1875.

† Annual report of the Bureau of Animal Industry, United States Department of Agriculture, 1885. Special report on hog cholera, *ibid.* 1889. Bulletin No. 6, *ibid.* 1894.

all important fact that it was a definite disease produced by a distinct species of bacteria. Subsequent investigations have shown that the spread of this disease and likewise its prevention are governed almost entirely by the conditions or agencies which favor or check the spread of this particular species of bacteria. It has been clearly established, therefore, that hog cholera is an infectious disease. Its specific organism is easily carried from an infected to a non-infected locality rendering the spread of this malady exceedingly easy, but still we believe largely within the power of man to control.

Symptoms.—There seems to be a popular, traditional belief that the nature of a disease should be determined by the objective symptoms. Such a belief is nearly fulfilled in case of certain affections but years of investigation have shown that with the one in question, it is not wholly true. This is unfortunate, but the best informed writers on the subject are agreed that hog cholera can not, with rare exceptions, be positively diagnosed by the symptoms. Animals suffering from various intestinal troubles frequently exhibit symptoms which very closely resemble those of hog cholera.

There are two recognizable forms of this disease, namely, the acute and the chronic or mild form. In the acute disease, the animals die very suddenly after a few hours or at most a few days sickness. In the other form the disease runs a longer course. There is usually a rise in the temperature of from 1 to 3° F.

The sick animals act dumpish, spiritless, and lie quietly in a corner or huddle together usually concealing the head in the litter. They refuse to move when disturbed and are more or less oblivious to their suffering. The appetite varies. In acute cases the animals may eat quite heartily up to within a few hours before death. In more chronic forms they eat fairly well until the end. There may or may not be diarrhoea. Frequently the bowels are costive. It is quite common in these cases to have an active diarrhoea during the last few days. The color of the discharge depends largely on the food. Vomiting rarely occurs. The changes in the respiration and the pulse are difficult to determine. There is rarely any

cough. Frequently there is considerable reddening of the skin on the nose, ears, abdomen and on the inside of the thighs and pubic region. The redness is diffused and more intense as death approaches, and frequently apparent in the dead animal. In some cases there is a discharge from the eyes. In the chronic form the animal becomes emaciated. These symptoms vary to such an extent that it is sometimes necessary to make a post-mortem examination, and even then the diagnosis must often be delayed until the results of the bacteriological examination are obtained.

Morbid anatomy, or the appearance of the diseased organs.—Hog cholera is a disease of the intestinal tract, although the lungs may occasionally contain areas of lobular or broncho-pneumonia. In the acute form the lesions are of a congestive or hemorrhagic nature. The lungs and heart may be sprinkled with bright reddish areas due to hemorrhages beneath the membrane covering these organs. The spleen is enlarged and the color much darker than normal. (See Fig. B. Plate II.) The kidneys are enlarged and usually their surface is of a dark color, due to the injection of the blood vessels. Frequently the intestines will contain blood clots. In some cases the hemorrhages are confined to areas beneath the mucous membrane of the stomach, especially in the fundus, but ordinarily the large and small intestines are also affected. In the chronic or less severe forms, which appear to be more common, the lesions are quite different. The spleen is very much enlarged, firm and dark colored. The lymphatic glands are enlarged and oedematous or hemorrhagic. In the caecum and upper part of the large intestine, and frequently in the lower portion of the small intestine, there are numerous ulcers. These are usually circular, slightly projecting masses of dead tissue, varying in color, but usually grayish yellow or blackish, or both, in alternate rings. They are readily recognized, and when associated with the large blackish spleen, the disease is almost always hog cholera. In some cases, instead of the isolated ulcers, the entire surface of the mucous membrane will be necrosed (dead), giving it a grayish or yellowish appearance.

Hog cholera is usually fatal and when it appears in a herd a large percentage of the animals are liable to be attacked unless rigid precautions are taken to prevent its spread. What these precautions consist in will be discussed on a subsequent page.

Although certain of the tissue changes appearing in hog cholera are simulated by other disorders, a careful post-mortem examination will, in most cases, enable the diagnosis to be made unless the disease is masked by various modifications or complications. In all cases the farmer should make, or have made, a careful post-mortem examination of any swine which may die, for the purpose of determining the nature of the affection. The common practice of allowing the dead animals to be buried without first ascertaining the cause of death should be discouraged. This has frequently caused the destruction of an entire herd from the disease, when, if properly handled at the beginning, a large proportion of the animals might have been saved.

The cause of hog cholera.—As previously stated this disease is due to the presence of a certain species of bacteria.* Without its presence, hog cholera is impossible. This organism is very small. It is rod shaped yet more than 15,000 of them could be placed end to end within the length of a single inch. They will live in water for several weeks and thus they are often carried from place to place in small streams. On account of their minuteness and their power to resist such natural agencies as moisture and dryness together with their ability to live for several months in the soil, it requires the greatest care to keep them off from one's premises, if they are present in adjoining herds. It seems to be difficult for people to realize that the exciting and only cause of this disease is a living organism invisible to the unaided eye. Let this fact be fully appreciated and the precautions about to be enumerated will be easily understood.

Prevention.—As hog cholera is caused by a specific organism the first fact to be determined is to find the channel or means by which it can be carried from an infected to a non-infected herd.

*For a full description of this organism see page 41.

The thorough investigations which have been made in the United States Bureau of Animal Industry (l. c.), have shed much light upon this subject. The observations of more recent years have confirmed the conclusion reached in the earlier reports of the Bureau. With these results and the experience of those who have acted upon their suggestions, we come to the consideration of the ways by which the virus is disseminated and the methods necessary for checking its spread, with an assurance of certainty that it can be kept away from individual herds even in the midst of wide spread epizoötics.

1. The virus of hog cholera is frequently introduced into a non-infected locality by the purchase of animals, usually for breeding purposes, from herds in which this disease exists or has existed within the preceding few months. These animals are usually placed among the home raised swine without quarantine thus affording every possible facility for starting up a new outbreak.

How could these animals carry the disease we are often asked? The answer is easy. The virus could be carried in the dirt on the animals, or, as is most usually the case, the pigs might have been but recently infected and later they develop the disease. It not infrequently happens that these animals are suffering, when purchased, from a chronic form of the disease, to which they eventually succumb. In purchasing swine, therefore, it is of the greatest importance that the history of the herd should show that it had been free from infectious diseases for at least one year. In addition to this, newly purchased swine should not be placed immediately after shipment in the pens with the home stock, but they should be kept in a separate enclosure until after all danger of the disease has passed.

2. Swine are often shipped in crates, boxes or in open cars, in which hogs affected with hog cholera have previously been confined. The history of hog cholera contains may illustrations of this method of contracting the disease.

3. As already stated, the bacilli of hog cholera live for a considerable time in water. On this account the specific bacteria

from outbreaks which start at or near the source of a creek or small river may be carried in the current, and infect animals which wallow in the stream many miles below. Although the illustrations of this method of infection are so numerous that they seem commonplace, it is the exception to find the swine kept from these possibly infected streams. An extensive outbreak occurred in the eastern part of the State of Illinois some years ago, which furnishes a good example of the significance of this neglect. Some breeding swine were purchased in a hog cholera district in the State of Nebraska. They were placed in a herd at the very head waters of a small stream. In about two weeks, hog cholera broke out among them and later it appeared in every herd, with one exception, for several miles along the infected stream. The hogs in the herd which escaped were confined in a yard some distance from the infected creek, carefully fed and kept dry, and everybody coming from the infected farms were forbidden to enter. This precaution saved the animals. Such a measure necessitates some work and a slight expense, but these are not to be seriously considered when by so doing the hogs can be marketed instead of lost. In the fall of 1895, I found in the State of Minnesota a few farmers who were adhering to this method and who saved their swine, while the herds of their neighbors were destroyed.

4. The bacilli of hog cholera can be carried in the dirt which adheres to one's shoes or to farming utensils. It not infrequently happens that the virus of this disease is carried from farm to farm on the tools taken from an infected place. It sometimes occurs that a farmer assists his unfortunate neighbor in drawing away or otherwise disposing of the dead or sick hogs and in turn carries the virus on his shoes or implements to his own herd. A very striking example of this came to the writer's attention in 1890. A farmer in Illinois, fearing the infection of his swine from a stream, confined them in two fields on a hill side. One day he assisted a neighbor in drawing out his dead hogs and, when through, left the stone boat which was covered with litter from the dead hogs, in his upper yard in which about sixty fattening

hogs nearly ready for the market were kept. In about two weeks they began to die of hog cholera. Then came heavy rains and about two weeks later the shoats in the lower field began to die of the same disease. He lost 158 of his 160 hogs. Although this man realized the danger of contamination from the stream, he failed to comprehend the fact that he could bring the virus in the way he did.

In the State of Minnesota, there is being carried out a method of individual quarantine which is working to a good advantage. The law provides that each farmer may, during the prevalence of infectious diseases among swine in his locality, post a notice warning all people from coming within 50 feet of the pens or yards in which his hogs are kept. The violation of this request is punishable by a heavy fine. If the disease is present then the State Health authorities post a notice of warning and forbidding any person, save the owner or the authorized attendants, from going to the pens. These notices enable farmers to keep their herds free from exposure to the virus of the disease through dirt brought by themselves or employes from infected localities.

5. The virus may be carried by buzzards, crows and other birds. There is no positive proof that the virus has been disseminated in this way although there is much evidence to support such a theory, particularly in the South. Several outbreaks have been attributed to this method of introducing the virus. The hypothesis emphasizes the necessity for promptly disposing of the dead animals instead of leaving them as prey for scavengers. If they cannot be burned it is best to cover the bodies with a liberal amount of lime and bury them.

Thus far we have considered the spread of the disease from herd to herd but it is exceedingly desirable to be able to check its ravages in herds which for any reason have actually become infected. It is obvious that this is a difficult task as all of the animals may have been exposed. For this reason it is often impossible to save any of the individuals. It seems to be a fact however, that usually only a few animals in a herd are infected at the beginning, and that the disease spreads from these. Here

as in dealing with infectious diseases generally, the principle of isolation is to be observed. If one or more animals are attacked, they should be separated from the apparently well ones. The as yet well animals should be placed in other pens, and the infected enclosure disinfected. The well ones should receive the best of care including good and wholesome food, pure water, a little salt, and if the animals are kept in a building it should be well ventilated. A laxative is also indicated. Dr. D. E. Salmon* recommends the following treatment for both prophylactic and curative purposes. It is reported to be more efficacious than any of the medicinal remedies previously tried. The formula for the preparation is as follows:

Wood charcoal	1 pound
Sulphur	1 pound
Sodium chloride	2 pounds
Sodium, carbonate	2 pounds
Sodium hyposulphite	2 pounds
Sodium sulphate	1 pound
Antimony sulphide	1 pound

These ingredients should be completely pulverized and thoroughly mixed. The dose of this mixture is a large tablespoonful for each two hundred pounds weight of hogs to be treated, and it should be given only once a day.†

If any of the animals among those supposed to be uninfected show symptoms of the disease, the well ones should again be re-

* Farmers' Bulletin No. 24, United States Department of Agriculture.

†Concerning this treatment the bulletin reads:

"When hogs are affected with this disease they should have at least once a day soft food, made by mixing bran or middlings and corn meal, or ground oats and corn, or crushed wheat with hot water, and stirring into this the proper quantity of the medicine. Hogs are fond of it; it increases their appetite, and when they once taste of food with which it has been mixed, they will eat it, although nothing else would tempt them."

"This medicine may also be used as a preventive, and for this purpose should be put in the feed of the whole herd. Care should of course be taken to see that each animal receives its proper share. In cases where it has been given a fair trial, it has apparently cured most of the animals which were sick and stopped the progress of the disease in the herd. It also appears to be an excellent appetizer and stimulant of the processes of digestion and assimilation, and when given to unthrifty hogs it increases the appetite and causes them to take on flesh, and assume a thrifty appearance."

moved to other pens. It is important that the pens should be kept dry. If board floors are used they should be cleaned frequently and suitable bedding provided. If floors are not used, dry ground should be selected and the inclosure should be changed from time to time. There is invariably enough organic matter in the water which collects in hog pens to provide pabulum for the hog cholera bacteria. In other words the swine should be isolated and the virus of the disease kept from them. As this disease is very similar to typhoid fever in man, the same general care should be exercised in warding it off that is employed in preventing the spread of that disease. The expense of the precautionary measures is comparatively slight, a mere trifle, compared with the loss from the disease, and it can therefore well be afforded.

If the post-mortem of the first animals to die show that the diagnosis of hog cholera is correct, it is recommended by some that all of the sick animals should be killed and their carcasses burned. There is logic in this method of treatment, as the mortality of hogs attacked with this disease is exceedingly high and if the individuals affected survive, they rarely become thrifty. Their destruction removes a source of infection and increases the prospect of checking the spread of the disease. Although this method has much to commend it, especially in the outbreaks where the disease in neighboring herds has run a rapidly fatal course, care in separating the well from the sick will often save several animals.

As the bacillus of hog cholera lives in the soil for several months, it is important that other swine are not brought to the infected place, before the virus has been destroyed. In cases where the sick animals are confined in pens or small inclosures, disinfectants may be used. Of these the following solution is effective. It is quite corrosive and care should be taken to protect the eyes and the hands from accidental splashing:

Crude carbolic acid ..... ½ gallon.
Crude sulphuric acid ..... ½ gallon.

"These two substances should be mixed in tubs or glass vessels. The sulphuric acid is very slowly added to the carbolic acid. During the mixing a large amount of heat is developed. The disinfecting power is heightened if the amount of heat is kept down by placing the tub or demijohn containing the carbolic acid in cold water, while the sulphuric acid is being added. The resulting mixture is added to water in the ratio of 1 to 20. One gallon of mixed acid will thus furnish 20 gallons of a strong disinfecting solution, having a slightly milky appearance. The mixture should be applied to the walls and floors of the pens, saturating them with it. Slacked lime would be less expensive for yards."

When the diseased animals have had a wide range it is best to allow the virus to become destroyed through natural agencies. It is not considered safe to reoccupy the land with swine within a year after the disease disappears. The writer has been told of several epizoötics among newly purchased swine placed in yards or fields in which animals have but recently died.

Treatment.— Naturally one looks for a remedy when the disease appears. It might seem unjust that the penalty of allowing the virus to enter must be the loss of a large part of the herd. However, this is usually the case. Nature as we find her is not relenting and when this virus is introduced, there is, according to past experience, little or no help to be obtained from drugs. Various medicines have been tried but thus far, they have not proved to be efficient. With this, as with other infectious animal diseases, the best treatment is to be found in their prevention.

During the past few years much has been said concerning preventive inoculation and more recently the serum treatment has received much attention. While there is hope that an antitoxin or other specific may be discovered, up to the present time these new remedies have not passed beyond the experimental stage, and one should be guarded against the purchase or use of any of these "sure cures" now on the market for hog cholera.

The United States Bureau of Animal Industry and also the investigators in some of the State experiment stations have been

and are still making extensive investigations in these lines, but as yet the desired results have not been fully attained. Farmers should not be hasty, therefore, in accepting these "new remedies" until they have a guarantee of their efficiency, at least in an experimental way. Again, the investigators who are searching for a specific for this disease, should not be blamed if they do not succeed at once. It is not yet known whether such a discovery is vouchsafed unto man. Certainly great benefit has accrued from the investigations already made. They have told us the cause, and pointed out the means by which it is possible, at least in a large majority of instances, to prevent the disease. It is highly probable that if we can have but one, a knowledge of the cause with the power to prevent can be made of more real value to the country at large than a medicinal remedy could possibly be.

Economic importance.—The economic importance of hog cholera (in which are necessarily included, on account of confusion in diagnosis, swine plague and dietary disorders) is much greater than is commonly supposed. According to the official reports of the United States Department of Agriculture, the loss of swine in this country from diseases, largely hog cholera, amounted in 1896 to 5,440,168 animals, or 12.7 per cent. of the entire number of hogs in the country. In 1896 the value of the swine in this State was estimated at $4,193,897. A loss of 12 per cent., the average loss for the country, would amount to more than half a million dollars. Already this disease has many foci in the State, and during the last year several outbreaks have occurred, in which the losses in the herds affected ranged from 40 to 90 per cent. Notwithstanding this, and contrary to certain rumors, hog cholera has not become a serious pest to the farmers of this State. However, if the natural history of this disease is carefully read, the conclusion must be reached that unless care is taken to prevent its spread, it may in a very few years become a wide-spread and destructive plague. Certainly the gravity of the situation should cause those who are personally interested to be cautious. If all keepers of swine would see to it that every reasonable precaution is taken to prevent the entrance

of the virus into their herds, and see that proper quarantine is enforced against all swine coming into the State from infected districts, hog cholera could undoubtedly soon be eliminated from within our boundaries. The situation is such that it is far more profitable to go to some trouble and expense to prevent the disease than to wait until it occurs and then try some supposed remedy.

It should be said further that the loss of the animals does not measure fully the cost of the disease. It frequently happens that the carelessness of a single man may permit the entrance of the disease into a locality from whence it spreads and often destroys the animals of those who are dependent upon the price of their "porkers" for the purchase of suitable clothing and necessary food. Such occurrences are not uncommon, and to prevent extreme suffering these people become temporarily public charges. It is a well-established fact in sanitary science that the health and prosperity of the people of a community depend largely upon the health of the domesticated animals in that community and upon which the inhabitants largely depend.

SWINE PLAGUE.

The term swine plague, like that of hog cholera, has been used indiscriminately to designate destructive diseases among swine. Swine plague, however, is primarily a disease of the lungs, although it may affect the other organs of the body. It is an infectious pneumonia. The difference between these two swine diseases may perhaps be made more distinct by comparing them to well-known human diseases. Thus the swine plague can be likened to pneumonia in man, and hog cholera to typhoid fever.

Swine plague was differentiated from hog cholera by Dr. Theobald Smith* in 1886. Up to that time it was unknown in this country, although a like disease, *Schweineseuche*, had been described in Germany. In addition to the difference in both the location and nature of the primary lesions, the bacteria which

* Report of the Bureau of Animal Industry, United States Department of Agriculture, 1886.

cause them are entirely different. (See description of hog cholera and swine plague bacteria on page 51.) Dr. Smith believed swine plague to be a distinct and independent disease, although it was often associated with hog cholera. In fact, he found the two diseases co-existing in the same outbreaks and often in the same animal. Other investigators, more especially Drs. Welch and Clements,* of Baltimore, have found them together so often that they were inclined to believe that swine plague was a secondary affection.

In 1895 the writer had an opportunity of investigating several outbreaks of swine disease in the State of Minnesota, where he found simple pneumonia, or swine plague, running a rapidly fatal course. These investigations, which cannot be entered into here, support the conclusion of Dr. Smith, that swine plague is an independent disease. During the past year it has been found in this State in two outbreaks in which the characteristic lesions or the bacillus of hog cholera were not discovered. In the examination of a dead hog the provisional diagnosis of swine plague may be ventured on the following appearances of the organs, viz.: A consolidation of a considerable part of one or both lungs, with the intestines, liver and spleen apparently healthy, although these organs are often more or less affected. If the intestines contain large ulcers and the spleen is very large and the glands of the mesentery are enlarged and oedematous the disease is very likely hog cholera. If all these tissue changes are found in one and the same animal it is presumable that both diseases are present.

Symptoms.— It is frequently difficult to recognize symptoms distinctive of swine plague. The peculiarities of swine render it exceedingly difficult to obtain evidence on physical examination of lung disease. Sometimes this affection runs a very rapid course but usually it is more protracted, lasting from a few days to a week or more. The affected animals eat very little, or refuse food altogether. They cough considerably especially when forced to run. The back is usually arched and the groins sunken.

* Paper read before the International Veterinary Association, Chicago, 1893.

The whites of the eyes are reddened. The skin over the under surface of the body, nose and ears is frequently flushed. The cough, however, is the most reliable indication we have of swine plague but in some cases of hog cholera the coexistence of broncho-pneumonia also causes the animal to cough when forced to move rapidly.

Morbid anatomy, or the appearance of the diseased organs.—Like hog cholera there are many known variations in the appearance of the internal organs of hogs which have died of swine plague. The characteristic lesions are, as previously stated, to be found in the lungs. Frequently the abdominal viscera appear to be normal although a careful examination will usually reveal slight changes. In the lungs, however, the disease is obvious. The delicate, light pinkish appearance of the normal organ is changed. The ventral and cephalic lobes and often a part of the principal lobe of one or both lungs have become solid. They are reddish, mottled or grayish according to the stage of the disease. The pleural cavity frequently contains a blood-stained or straw-colored liquid and the surface of the lung is sometimes covered with a grayish exudate which occasionally attaches the lungs to the wall of the cavity. In some cases there are obvious changes in the intestines, kidneys, spleen and liver. The extent to which these organs may be affected is not fully determined. In cases where the variations are marked it is impossible, even for experts, to make a diagnosis without a careful bacteriological examination. It is believed by the writer that swine plague may appear as a septicaemia in pigs, resembling very closely anatomically the acute form of hog cholera. If the disease exists in a modified form the assistance of a veterinarian will be necessary in making the diagnosis. It is not too much to expect that all those who raise swine should be able to determine whether or not the changes characteristic of the typical forms of this disease are present. An early diagnosis and prompt preventive measures will often save serious loss and hence the desirability of having the farmer able to take the initiative steps in preventing its further spread.

The cause of swine plague.— Dr. Theobald Smith* discovered in 1886 that this disease was due to a small non-motile bacillus. It differs radically in both its morphology and cultural characters from the bacillus of hog cholera. Although there has been considerable confusion concerning these two species, it is safe to say, as will be seen from their description on page 47, that they can be easily distinguished the one from the other. Dr. Smith also found that an organism closely related to, if not identical with, the bacillus of swine plague exists in the upper air passages of a large percentage of healthy swine. It is interesting to know that similar bacteria live in the mouth and trachea of many cattle, cats and dogs. Surgeon-General G. M. Sternberg, as early as 1881, showed that in human saliva there is a bacillus which is supposed to be identical with that of pneumonia in man.

The discovery of this bacillus in the upper air passages of healthy pigs is of much importance as it explains the presence of the bacillus in isolated or sporadic cases of pneumonia. The history of swine plague indicates, however, that in outbreaks of the disease the specific organisms are transmitted from animal to animal. It is still an unsettled question whether or not in the beginning of an epizoötic, the disease starts from a sporadic case, that is, one which developed from the normally present organism under certain favorable conditions, or, from an infection following previous exposure to the disease. An argument in favor of the infectiousness of the disease rests in the fact that the mortality in herds affected with epizoötic swine plague is much higher than the percentage of swine which have been found to normally harbor the identical or closely related species of bacteria in their air passages.

At present we must consider epizoötics of swine plague to be due to an infection with the specific organism (the bacillus of swine plague), as its clinical history shows it to be an infectious disease which often becomes widespread.

In the sporadic cases the conditions under which the animal was kept must be taken into account. While in a measure dis-

* Special report on swine plague, Bureau of Animal Industry, 1891.

tinct, the possible relation between the sporadic and epizoötic forms of pneumonia appear to be close and dependent to a certain degree upon purely external conditions. This emphasizes the importance of keeping swine in the best possible sanitary conditions. The investigations which have been made into a few epizoötics seem to indicate that the disease sometimes starts in a sporadic case from which it spreads to the other animals in the herd.

Prevention of Swine plague.—Recent investigations in Minnesota and Illinois show that outbreaks of swine plague are much more extensive than heretofore supposed. The present knowledge of this disease indicates, therefore, that the adoption of measures for its prevention is quite as important as for hog cholera. In general the measures to be adopted and followed, and the rules to be observed in the prevention of epizoötic swine plague are practically the same as those for the prevention of hog cholera. It will be seen from the comparison of the two species of bacteria that the bacillus of hog cholera is a more hardy organism than that of swine plague. Thus the swine-plague bacillus is destroyed more rapidly by drying and will live a much shorter time in the soil. However, the channels through which it may gain access to a herd are practically the same, and every precaution suggested in reference to hog cholera, is applicable to swine plague. It is believed that the time during which a field, hog yard, or pen should be kept free from swine after the appearance of the disease can, with safety, be shorter after swine plague than after hog cholera. In any case several months should elapse before the yards or pens are reoccupied.

Treatment of swine plague.—A discussion of the disease would not be complete or satisfactory to the practical mind unless a method of treatment is prescribed. The discovery of an efficient remedy would unquestionably increase the prospects and raise the hopes of many hog raisers. At present, quacks flood the infected districts with their "curative wares" without giving evidence of the virtue of their drugs.

For a number of years investigations have been almost constantly under way in the United States Bureau of Animal Industry, for the purpose of finding some method by which this disease could be successfully treated when introduced into a herd. Drugs and medicines have been tried, preventive inoculations and injections of toxines have been made. The serum therapy which has afforded relief in other diseases is now being tested with somewhat favorable results, yet we are compelled to say that a specific has not been demonstrated. In view of this unfortunate fact, it becomes necessary to apply with renewed zeal our present knowledge of the nature of the malady and endeavor to prevent its occurrence or reappearance by keeping the animals under the best possible conditions. Prevention of the disease is the key to success. We hear about sterilized milk and testing cows for tuberculosis, not that these will cure, but that they will give information which can be used in such a way that it will minimize the further spread of the disease. So with swine plague. Let every farmer quarantine his swine against all possible sources of infection; keep his animals clean, and supply them with plenty of good food and water and there is reason to believe that he will have little or no occasion to use medicinal remedies.

DIETARY AND FILTH DISORDERS.

It is the experience of those who are engaged in the investigation of infectious diseases to find destructive outbreaks of a peculiar nature among swine kept in filthy pens and yards and also among those fed upon garbage collected in our villages and small cities. A study of the animals which die in these outbreaks shows frequently that the disease is not hog cholera or swine plague, as reported, for neither the changes in the tissue or the results of the bacteriological examination confirm such a diagnosis. It has already been pointed out that in order to have these infectious diseases, the specific bacteria which produce them must be present, and usually they can be easily detected. The causes of death which occur among swine kept under these unsanitary conditions are spoken of as dietary or filthy disorders.

Although the cause of these deaths is usually attributed to hog cholera, the typical character of the lesions are enough to show the error in this diagnosis.

From the fact that as yet the specific cause of death among these garbage or swill fed hogs has not been definitely pointed out, the opinion is commonly entertained by the people who feed such material and who frequently keep these animals in a disgustingly filthy condition that the cause of death is some contagious disease. By this means they endeavor, consciously or otherwise, to shift the responsibility for the loss which they have sustained.

It is an unhappy fact that many of these people honestly think that "anything is good enough for a hog," and it is hard for them to conceive that unwholesome food and excessively filthy surroundings could lead to fatal results. But it is a significant fact that in this State the great majority of deaths among swine are among the poorly kept and usually garbage-fed animals and ordinarily the cause of death is not, so far as has been learned, a bacterial disease. The investigations which we have made during the past summer show that very probably one of the causes of death among animals fed upon the slops (including dishwater) from hotels and boarding-houses is poisoning by carbonate of soda (washing soda) which comes from the powdered soaps now used so extensively in the kitchen. At least it has been found that it requires a less quantity of powdered soap in the food to kill pigs experimentally than is used in many public and even private houses for cleaning dishes. The heavy losses sustained from deaths among swill-fed hogs, together with the unwholesomeness of garbage as animal food, suggests the desirability of discontinuing the practice of collecting kitchen slops for this purpose. In the State of Minnesota I am told there is a law forbidding it. The use of table refuse and waste bits of vegetables can undoubtedly be used with safety if they are fed while fresh and sweet. Certainly pure water is much more desirable for drinking purposes, even for swine, than dish water. For a further discussion of this subject the reader is referred to Bulletin No. 141 of the Cornell University Agricultural Experiment Station, 1897.

II.

SERUM THERAPY IN INFECTIOUS SWINE DISEASES.

As methods for the production of immunity have not, after years of the most untiring and careful investigation, reached a practical basis, attention has been directed to the treatment of these diseases with the blood serum from immunized animals. The successes which have been obtained with the diphtheria and tetanus antitoxines suggested that perhaps similar results might be realized with the swine diseases, and already there has been much activity exhibited in exploiting the possibilities of this new field. Many of the efforts appear to have been fruitless, but others are giving promise of success. The fact should not be lost sight of that in these diseases, more, perhaps, than in any others, there are complications by way of mixed infection, and the effect of unwholesome food and bad environment, which may materially interfere with the neutralizing action and final result of the antitoxin.

Lorenz* seems to have been the first to use serum therapy on swine with success. He worked, however, with *rouget*. After immunizing guinea-pigs and rabbits against this disease, he used their blood to immunize swine. This being successful he used their blood in immunizing other swine. The method is reported to be fairly satisfactory.

In the fall of 1896 two papers on serum therapy in American swine diseases appeared which indicate that at least some of the difficulties heretofore experienced in the direct use of the bacterial products are being overcome. The first of these was by Dr. E. A. deSchweinitz† of the Bureau of Animal Industry United States Department of Agriculture. He used antitoxin serum which was prepared by repeatedly inoculating a cow. With the blood serum of this animal positive and constant results were obtained in guinea pigs. The amount of antitoxin required was 6 c. c. per pound weight of guinea pig. We are promised in the paper a full account of this and other experiments in this line.

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* Deutsche Zeitschrift für Thiermedicin, Bd. XX.

† Proceedings of the Society for the Promotion of Agricultural Science, 1896, p. 47.

Dr. A. T. Peters,* of the Experiment Station of Nebraska, presented the other communication at the meeting of the United States Veterinary Medical Association. He inoculated horses with virulent cultures of the hog cholera bacillus, beginning with 5 c. c. and increasing the quantity until 20 c. c. was given at a time without apparent discomfort. After the animal ceased to react to the cultures, a small quantity of the blood was drawn and tested on rabbits after the method used in testing diphtheria antitoxin on guinea pigs. When the horses were sufficiently immunized, their serum was tried on swine. His laboratory experiments show that it took from 8 to 10 c. c. of the undiluted serum to make a hog weighing 150 pounds immune to hog cholera. At the writing of his paper the serum had been tried in about 23 herds reported to be affected with hog cholera. From several of these encouraging results had been obtained.

The criticism on the paper as brought out in the discussion which followed it, is that positive evidence of the accuracy of the diagnosis of the disease in the herds in which the serum was used was not procured. Further, the usual mortality in similarly affected herds which were not treated is omitted. If the disease which he treated in the field was genuine hog cholera his results are very promising.

Soon after the publication of the last-mentioned papers, Perroncito,† announced the discovery of a vaccine for hog cholera. This I am told is a blood product. It has become an article of commerce without having, to my knowledge, its efficiency verified for the disease as it occurs in this country. From the notice and circulars sent out 3 c. c. is the dose, regardless of the age or weight of the animal. In France the sale of serum is authorized by law only after the Academy of Medicine has given its approval to samples and inspected the laboratories where they are made, but the farmers in this country are not similarly protected either by State or national laws.

* Serum therapy in hog cholera. Proceedings of the United States Veterinary Medical Association, 1896, p. 59.

† Noticed in Recueil de Medecine Vétérinaire, VI (1897), p. 71.

An experiment with the swine-plague serum prepared by the Bureau of Animal Industry.—In January last, I made at the request of Inspector Quigley an investigation into the nature of an infectious disease which was destroying many swine in a herd near Auburn. As stated by the owner, the herd originally consisted of 72 animals, mostly shoats, a few of which had been purchased in the vicinity and the others raised on the place. They had run together about the farm yards until late in the fall when they were divided into three lots and penned.

In pen No. 1, were put 14 yearling hogs weighing about 250 pounds each.

In pen No. 2, were put 37 black and white shoats weighing about 60 pounds each.

In pen No. 3, were put 21 white shoats weighing about 40 pounds each. Pens Nos. 1 and 2 were in the same building but separated by a tight partition and several feet of floor space. Pen No. 3 was a building by itself standing about 300 feet from the first. The animals were fed on swill obtained from the State prison at Auburn. Late in December the pigs in pen No. 2 began to sicken and die. The symptoms were said to be the refusal of food and a bad cough which developed a few days before death. A little later the older hogs in pen No. 1 were attacked and nine of them died.

At the time of my first visit (January 28th) about 40 animals had died. Those which I found living were in pens as follows:

In pen No. 1, there were five hogs all apparently well.

In pen No. 2, there were four shoats all sick.

In pen No. 3, there were 19 shoats all apparently well.

In pen No. 4, there were two pigs which had been taken from pen No. 2, after the disease had appeared. They were both well.

In pen No. 5, there was one pig which had been taken from pen No. 3, because it looked sick.

The animals, up to this time, had died at the rate of one or two a day after a sickness of from one to three weeks duration. I found two dead hogs from pen No. 1. They had been dead about ten and twenty-four hours respectively. Just before my ar-

rival one of the pigs from pen No. 2 had been killed by Mr. Quigley in what was thought to be the last stages of the disease and sent to me by express. It was received and examined the following morning. The two old hogs were carefully examined.

The lesions found in both of these animals were extensive hepatization of the lungs. The cephalic, ventral, and a portion of the principal or caudal lobes were involved in both animals. In one of them there was extensive pleuritis. The spleens were slightly enlarged and dark-colored. The mesenteric glands were enlarged and hyperaemic, in a few instances the cortex was hemorrhagic. This was especially true with those in the smaller curvature of the stomach. The intestines presented a few areas of hyperaemia but no distinct lesions. Tubes of agar inoculated from the spleen and lungs gave pure cultures of swine-plague bacteria. Rabbits inoculated with pieces of the hepatized lung died of swine plague on the fifth day. Those inoculated with the culture died in a short time.

The small pig did not show any decided lesions. Tubes of media inoculated from its organs either did not develop or they contained impure cultures of saprophytic bacteria.

As the disease appeared to be uncomplicated swine plague, it seemed to be a suitable outbreak in which to try the serum therapy. Prior to this I had been requested by Dr. E. A. deSchweinitz, of the Bureau of Animal Industry, to test this serum if an opportunity arose. While this was by no means the ideal time in the course of the outbreak to begin, it was thought best to try it. Unfortunately only a small quantity of the serum was obtainable at this time.

February 2d, I again visited the outbreak, in company with Mr. Quigley, for the purpose of injecting the serum. We found that no deaths had occurred since our former visit, but that the disease had appeared in pen No. 3, and three of the pigs were very sick. In selecting the animals upon which to try the serum, the wishes of the owner were observed. The animals chosen were as follows:

In pen No. 1, two hogs received subcutaneously 24 c. c. each; one hog received subcutaneously 12 c. c.; two hogs were reserved for checks.

In pen No. 2, four pigs received subcutaneously 12 c. c. each.

In pen No. 3, three pigs received subcutaneously 12 c. c. each.

These were sick. They were removed to another pen. In pen No. 5, one pig received subcutaneously 12 c. c. Sick.

February 18th, I again inspected the animals and found three of the treated ones dead. These were: One from pen 2, one from pen 3 and the one in pen 5. These were carefully examined and the lesions were those of swine plague. The lungs were more or less hepatized. The spleens were slightly enlarged and the mesenteric glands were enlarged and oedematous. The intestines were normal in appearance. From two of the animals the swine-plague bacillus was obtained. Cultures were not made from the third, on account of advanced post-mortem changes. The remaining pigs in pen No. 2 were no worse and the other two from pen No. 3 were decidedly better.

February 27th, I found a second pig dead from pen No. 2. The disease had again appeared in pen No. 3 and one animal had died. The post-mortem examination of these two pigs showed extensive lung disease. The intestines were not affected. Rabbits inoculated with bits of lung tissue of the pig from pen 3 died on the sixth day with attenuated swine plague, as shown by extensive pleuritis.

At the request of the owner, more of the serum was obtained, and on March 1st the remaining pigs in pen No. 3 were injected. Since February 27th, two had died, leaving but thirteen still living. More than half of these were coughing. They were all injected subcutaneously in the groin with 12 c. c each of the swine-plague serum. The two dead pigs were examined and the lesions found to be restricted to the organs of the thoracic cavity.

During the next two weeks five of the pigs treated March 1st, died. They were not examined, as notice of their death was not received until some days later. The other eight remained well or recovered, and subsequently they were reported as being

thrifty. I saw them the latter part of April and they looked perfectly well. The two survivors of the first lot of three from this pen recovered rapidly. Some weeks later the two pigs in pen No. 2 died. None of the hogs in pen No. 1 were attacked after the treatment. They were sold late in March.

To summarize, there were, on February 11th, eleven animals treated, of which six died. Eight of the eleven were obviously sick at the time they were given the serum. Later thirteen animals were injected; of these, eight were sick at the time of treatment; of these thirteen, five died. Of the total of twenty-four treated, eleven died and thirteen survived.

In drawing conclusions from this experiment several facts must be taken into consideration. Although all of the animals were not examined, there were enough post-mortems to show that the disease was very probably uncomplicated swine plague. It did not spread, however, to other herds in the locality. At the time the treatment was begun, forty animals had died, so that among the survivors we may have had those possessed of strong resisting power. Again, the virus obtained from the different animals was of the attenuated form, showing that possibly the disease was well-nigh spent at the time the treatment was begun.

On the other hand, the disease among the pigs in pen No. 3 did not appear until just before the treatment. The owner had tried to keep these animals isolated from the others, but in spite of his efforts there was much running by the farm hands from pens 1 and 2 to this one. The perfect recovery of two of the very sick pigs first treated from pen No. 3 is suggestive of a specific action on the part of the serum. Again, all of the animals attacked and which were not treated died, while of the twenty-four treated, at least sixteen were obviously sick at the time, and of these at least four recovered. The pigs did not receive the care, either in protection from cold and wet or in their food, that good farm hygiene demands. All things considered, therefore, the results are, if taken at their worst, encouraging. Certainly the investigations along these lines are more promising for the final discovery of a specific for this disease than along any others which have been proposed.

III.

INVESTIGATIONS INTO THE NATURE OF THE DISEASE IN CERTAIN DESTRUCTIVE OUTBREAKS AMONG SWINE.

During the past year a careful and as thorough an investigation as the circumstances permitted has been made into the nature of the disease in several quite serious outbreaks among swine. These have been made in part under the auspices of the New York State Veterinary College and in part at the request of the Hon. C. A. Wieting, Commissioner of Agriculture.

It is of interest to note that in all of the more important outbreaks which are here reported, the disease was popularly called hog cholera. The work which has been done and which from necessity has been somewhat fragmentary and largely diagnostic in nature, has shown that certain of these outbreaks were not due to any known infectious disease. The cause of the deaths seemed to be attributable to the bad hygiene. So long as the owners felt that the trouble was due to a contagious disease, they believed themselves helpless, but when they were shown that the losses were not due to such causes, but probably to local conditions, the "scare" was usually allayed and efforts put forth to correct the evil. When the real nature and local causes of these outbreaks are more fully and correctly understood, there is little doubt that the sanitary and hygienic conditions will be improved, and, as a result, the total amount of loss annually sustained from these causes, will unquestionably be reduced by thousands of dollars.

Emphasis should be placed on the question of diagnosis. It has been pointed out in the first part of this report that to make the diagnosis of hog cholera it is necessary to find certain kinds of tissue changes and the presence of the specific bacteria. If the changes in the organs are not like those described for hog cholera, and if the bacillus of hog cholera cannot be found in the organs of the dead animals, it cannot be affirmed that the disease is hog cholera. The same criterion must be applied to swine plague, anthrax and tuberculosis.

Outbreaks near Rome.—(A.) *Disease at the Oneida County Home,* Nov. 17th, 1896, I made, at the request of Dr. Huff, an investigation into the nature of the disease among swine, reported to be both hog cholera and scarlatina, affecting the hogs at the Oneida County Home. Dr. W. H. Kelly, of Albany, and Inspector Quigley, representing the Department of Agriculture, were also present at the examinations. The history, as related by the superintendent, showed that about 70 small pigs, about six weeks old, and 8 fattening hogs had died. There were about 40 fattening hogs and a few shoats still living, and, with few exceptions, apparently in good health. The animals were kept in pens which opened into a yard in which horse manure had been placed in considerable quantity, and in which the offal from several cattle which had been slaughtered for beef had been thrown . The fall rains had left the yard very wet and the offal was badly decomposed. The pens themselves were found to be well kept. Although the yard was not more filthy than it is the custom of many people to permit, and even to think proper for swine, it was not a suitable place for keeping animals of any kind. The food consisted of the table refuse from the house, cooked potatoes and soft corn.

The disease first appeared about two weeks before this, when 35 of the pigs were found dead and a few others sick. As soon as the disease appeared among the old hogs they were, at the suggestion of Dr. Huff, all turned into a grove, with the result that only eight died. The cause of death was thought to be some infectious disease, although, so far as known, there had been no chance of infecting the herd. Hog cholera or swine plague was not known to have existed in the vicinity and new animals had not been introduced. The men in charge had not been off the farm and food liable to have been infected had not been purchased. Owing to the large number of hogs still remaining and in a condition ready for slaughter, it was very desirable to determine, if possible, the nature of the disease. This could only be done by making a careful post-mortem and bacteriologic examination of such animals as were suitable for this purpose. Of

these there were but three. Two of them had died the night before and the other was sick at the time. All of these were carefully examined.

Post mortem examinations.— Pig No. 1, Berkshire female three months old, weight about forty pounds. Died during the night. Post-mortem held at 9 a. m. Skin on the throat was covered with pink blotches, darker colored blotches nearly covered the skin between the fore legs and over the abdomen and thighs.

Lymphatic glands of the inguinal region, also those in the vicinity of the head, slightly enlarged and oedematous, cortex hemorrhagic. Right lung sprinkled with a few ecchymoses, otherwise normal. The tip of the cephalic lobe of the left lung hepatized; the ventral and principal lobe slightly congested (hypostatic).

Pericardium normal. In the left ventricle of the heart was a small number of blackish clots. Right ventricle contained a larger quantity of post-mortem clots.

Liver somewhat pale. Gall bladder contained a small amount of clear yellowish bile. Spleen dark colored, but not enlarged. On the ental surface there were a few small blood tumors. The left kidney was considerably enlarged, capsule easily removed, cortex sprinkled throughout with a large number of punctiform hemorrhages varying in size from a mere point to 2 mm. in diameter; pyramids normal; pelvis was filled with a dark clot. The right kidney presented the same appearance. The bladder contained about 5 c. c. of blood-stained urine.

The mesenteric glands were slightly enlarged, cortex of many of them hemorrhagic, others very dark colored, showing evidences of older hemorrhages. Stomach glands considerably enlarged and pigmented.

Stomach contained a moderate quantity of partly digested food. There were a few ecchymoses in the mucous membrane near the pyloric orifice. The mucous membrane of the duodenum was pinkish with areas of blood extravasation. The mucosa of the jejunum, apparently normal. The ileum contained a considerable amount of blood-stained mucus, also a few small blood clots. The capillaries of the mucosa were considerably injected. In the lower two feet of the ileum the mucous membrane was covered with a thick layer of blood-stained mucus. The mucous membrane of the caecum and colon contained hemorrhagic areas. Lower colon contained a considerable quantity of semi-liquid feces and earth which were slightly blood stained.

Bacteriologic examination.—Several tubes of agar and gelatin were inoculated with bits of the tissue from the lung, liver, kidney, spleen, mesenteric glands and with the heart blood. Rabbits were inoculated on the following day with pieces of the consolidated lung and lymphatic glands.

The tubes of media inoculated remained clear with a very few exceptions and those contained ordinary saprophytic bacteria. The rabbit remained perfectly well. There was not even visible inflammatory reaction at the place of inoculation. From the various organs which were brought to the laboratory cover-glass preparations were made and stained for bacteria. They did not reveal the presence of microorganisms.

Pig No. 2. Chester white, eight weeks old, weighing about fifteen pounds, male, had been sick about one week, poor condition. Skin over abdomen, inside of thighs, and over throat, of a pinkish color. Lungs and heart normal, spleen, liver, and kidneys apparently normal. The mucous membrane of the small intestines were slightly reddened. Mesenteric glands enlarged. The fundus of the stomach hyperaemic, no ulcers.

Bacteriologic examination.—Tubes of culture media were inoculated with the blood and bits of various organs. They remained clear. Bacteria could not be found on a microscopic examination in stained cover-glass preparations made from the blood, glands, liver and spleen.

Pig No. 3. Jersey red, about four months old, weighing about seventy-five pounds. It had been sick for two weeks. It refused food, walked with an unsteady gait. No diarrhoea, was killed for examination. Not emaciated. The inguinal glands were considerably enlarged, slightly oedematous, cortex hemorrhagic. Lungs partly collapsed. Left lung contained several small areas of hepatization in the cephalic and ventral lobes. Surface of the entire lung sparsely sprinkled with ecchymoses. The tips of the cephalic and ventral lobes of the right lung were hepatized, less number of ecchymoses than the left lung. The bronchial glands were enlarged and hemorrhagic. The pericardial sac contained about 100 c. c. of clear straw-colored serum. Surface of heart nearly covered with irregular areas of blood extravasations. The liver was firm and sprinkled with bluish areas due to thickening of the capsule. The interlobular tissue was much increased. The spleen was slightly enlarged, darker than normal but the pulp was soft. The left kidney was large, capsule easily removed, pale, cortex rather firm, the medullary portion swollen, the pelvis normal, the stomach and mesenteric glands were enlarged and the cortex deeply reddened. The mucous membrane of the intestines was normal, and of the stomach pale. Bladder contained about 100 c. c. of clear urine.

A careful bacteriological examination was made of the various organs with negative results. Rabbits were inoculated with bits of the affected lung tissue, kidney and mesenteric glands. These animals remained well.

It is probable from the variety of lesions found in the animals examined and the negative outcome of the bacteriological examinations that the disease was not of a specific bacterial origin. Theoretically there were conditions which might explain the cause of death, but which we were not able to demonstrate. There are reasons other than the negative bacteriologic results,

which indicate that this was not hog cholera, but that the deaths were due to local causes. These are:

1. There was no known exposure to the disease and hog cholera had not appeared in the neighborhood.

2. The first indication of disease in the herd was the finding at one time of about 30 dead pigs, and several others sick. All of these seemed to have been well the day before. Subsequently very few others were attacked.

3. The other animals which died were sick for various lengths of time.

4. Although all the old hogs were exposed and many of them were sick, only eight died, the others recovering rapidly after they were placed in the open field.

5. The disease did not spread from this to other farms.

(B.) *Disease among swill-fed hogs.*—At the request of Dr. Huff, we visited the farms of two men residing a few miles out of Rome who had lost about 40 hogs each, from what they thought was hog cholera. We found that each of these men had quite extensive garbage routes in the city of Rome, and were feeding swill thus collected to their hogs. Unfortunately, at the time of our visit the animals were nearly all dead and badly decomposed so that post-mortem examinations were impossible. The symptoms as related, however, were very irregular and the period of duration of the disease variable. The facts which impressed us were the rotten garbage which was being fed and the disgustingly filthy condition of the pens and yards in which the animals were kept. It is exceedingly unfortunate that a specific disease like hog cholera should be accused of being the cause of death of all animals in herds kept under such conditions and before a careful examination has been made.

The losses in these three outbreaks were not less than 150 animals of which fully eighty hogs were nearly ready for the market. According to the owners, the value of these animals was more than $1,200, and a conservative estimate would be not less than $800. Besides this there was a loss of seventy pigs and shoats.

Outbreak near Oswego.— During the summer and fall of 1896, several outbreaks of disease among swine occurred near Oswego. These were thought, by Dr. Poucher, to be largely due to hog cholera. The outbreaks were for the greater part in the herds fed upon garbage and swill collected from hotels and boarding houses in the city. Late in the fall, a disease appeared among the hogs in a herd fed upon the garbage collected from a single large boarding house. From this herd the disease spread to several others, causing the loss of many animals. December twentieth, I made, with Dr. W. H. Kelly of Albany, an examination of one of the animals which had died the day before in the last herd affected in the above-mentioned outbreak. The condition found is indicated in the appended post-mortem examination notes.

Post-mortem examination.— Chester white, female, weight about 200 pounds. It was reported to have been sick some days and to have coughed considerably. The skin over the ventral surface of the body was slightly pinkish in color. The mouth and tongue were normal. The left pleural cavity contained about 500 c. c. of blood-stained serum. The left lung was partially collapsed. The cephalic half of the principal lobe was firmly hepatized. The entire right lung was consolidated, it was of a dark reddish color and upon section the interlobular tissue was oedematous. A few of the lobules were hemorrhagic. The bronchioles contained little mucus. There were no adhesions between the lungs and the thoracic walls. The azygos lobe contained a few hepatized lobules. Otherwise it was normal in appearance. The bronchial glands were enlarged, hyperaemic and the pulp abnormally soft. The spleen was enlarged and of a dark color, the kidneys were large, the cortex apparently thickened, and the medullary portion pale. The capsules were easily removed. The left kidney contained several punctiform hemorrhages. The mucous membrane of the caecum and colon was dark colored.

The mucosa of the fundus of the stomach was blackish and on section showed extensive hemorrhages. There were no ulcers. The lymphatic glands, especially those in the smaller curvature of the stomach, were enlarged and dark colored.

Bacteriologic examination.—A number of tubes of agar, gelatin and bouillon were inoculated from the hepatized lung tissue, the heart blood, and from the liver and spleen, with the exception of the gelatin, those inoculated from the blood, liver and spleen and most of those from the lung contained on the following day pure cultures of the swine-plague bacillus. Cover-glass preparations made from the lungs contained swine plague bacteria in large numbers. Very few were found in preparations made from the spleen.

Two rabbits were inoculated with bits of the diseased lung December 22d. They died from swine plague septicaemia, one in 16 and the other in 18 hours.

The microscopic examination of the sections of the pneumonic lung showed in addition to the cellulur changes characteristic of the disease large numbers of swine-plague bacilli.

This was an unquestioned case of swine plague or infectious pneumonia. From the history given it is presumable that the other animals in this and adjoining herds had died of pneumonia. As soon as the diagnosis was made the Assistant Commissioner of Agriculture, assisted by Drs. Kelly and Poucher, took active measures to check the spread of the disease. For details concerning the destruction of the remaining animals and quarantine see Dr. Kelly's report.

Outbreak near Auburn.—January 28th, 1897, at the request of Inspector Quigley, I examined, with him, animals in a herd near Auburn, which were dying of a disease thought to be hog cholera. Already about 40 shoats and fattening hogs had died. They were fed upon the garbage from the State Prison at Auburn. The examination of two animals showed lesions characteristic of pneumonia or swine plague. Subsequently several others were post-mortemed in this herd, all of which exhibited pneumonic lesions, and from which the swine-plague bacillus was obtained.

As I had been requested by Dr. E. A. deSchweinitz, of the Bureau of Animal Industry, United States Department of Agriculture, to test the swine plague antitoxin which was being prepared by the Bureau, arrangements were made for doing so on this herd. The full report of this experiment, with the further particulars obtained concerning the nature of this disease, were described on page 23.

An outbreak of a mixed infection of hog cholera and swine plague at Fishkill Landing.—At the request of Dr. H. E. Allison, medical superintendent of the Matteawan State Hospital, at Fishkill Landing, an investigation was begun May 6th, 1897, for the purpose of determining the nature of a destructive disease which had appeared among the hogs on the farm belonging to that institution. The herd consisted of eleven breeding sows, two boars,

sixty-two shoats and seventy-six small pigs. Up to this time twenty-one shoats had died.

The hogs were housed in well-kept pens, each of which opened into a good-sized yard. The ground in the yards was dry, with the exception of a few holes, which contained muddy water. The land was rather low. A number of shoats had been turned into a piece of cleared woodland adjoining the fields in which the pens were located. In this woodland there were several wet, marshy places. The hogs were fed the table refuse from the hospital. It was carefully sorted and fed while fresh. In preparing the food it was put into a trough, thoroughly mixed with water and considerable wheat bran was added. During the winter the food was cooked before feeding and the kitchen refuse was never kept over from one day to the next.

The disease first appeared about the end of the first week in April, when a few shoats were affected. It gradually extended to others and nearly all of those attacked died. They were sick from a few hours to several days. The symptoms were reported by the man in charge of the animals to have been exceedingly variable. Usually there was a cough, and a partial paralysis of the hind limbs. In a few animals the skin over the abdomen was of a pinkish color. Some of the hogs had a diarrhoea; others were constipated. A post-mortem examination was made by the man in charge on a few of the animals which died early in the outbreak. He reported finding the "lungs in a very bad condition." At the time of this visit four animals were carefully examined post-mortem.

Pig No. 1.—Female, two years old, weight about 250 pounds. She had recently given birth to several pigs. She had been sick but a short time. The examination was made not over two hours after death. A little blood was oozing from the nostrils. The skin was not discolored. Upon section the flesh was normal in appearance. The liver was deeply reddened due to engorgement of the blood vessels. Blood flowed freely upon section. The spleen was slightly enlarged and dark colored. The kidneys were hyperaemic, especially the medullary portion. In the pelvis of the right kidney there was a large blood clot. The mucous membrane of the intestines was normal with the exception of several irregular areas of hyperaemia. In the fundus of the stomach was a large, dark blood-clot.

No ulcers. The mesenteric glands were enlarged and darker than normal. In a few cases the cortex was hemorrhagic. The right lung was in a state of hyperaemia. The heart contained very little liquid blood.

Bacteriologic examination.—A few bacteria were found in stained cover-glass preparations from the spleen and liver. Two tubes of agar were inoculated with bits of the tissue from the hyperaemic lung, liver, spleen and kidneys. These tubes developed cultures of the hog-cholera bacillus. A few of them were pure cultures; the others contained, in addition to the hog-cholera organism, a quite large bacillus.

May 8th, rabbit No. 35, was inoculated subcutaneously with 0.5 c. c. of a dilute suspension of the growth from one of the spleen cultures.

May 15th, rabbit died this morning. The post-mortem examination showed the liver to be pale, the spleen very much enlarged, dark colored and friable. The kidneys were slightly hyperaemic. The intestinal tract normal. The heart sprinkled with ecchymoses. Cover-glass preparations from the various organs showed many small bacilli. Pure cultures of the hog-cholera bacillus were obtained from the heart blood and spleen. The bacillus obtained from this animal was carefully studied and cultivated on the various media. It was found to differ from the type of *B. cholerae suis* in producing indol. The nonpathogenic organism found to be associated with the hog-cholera bacillus in this animal has not been specifically determined but it is believed to be one of the normal intestinal forms.

Pig No. 2.—This hog died during the night and had just been buried. Male weighing about 50 pounds. It had been sick for several days. The skin over the abdomen was deeply reddened. The liver was firm the interlobular connective tissue thickened, the centers of the acini were deeply reddened. Spleen slightly enlarged and dark colored. The kidneys were hyperaemic and the cortex of each thickly sprinkled with punctiform hemorrhages. The mesenteric glands were enlarged and pigmented. The intestines appeared to be normal. The stomach contained undigested food and earth. The mucous membrane over the fundus was hyperaemic and contained several hemorrhagic areas. The right lung was hyperaemic and contained several areas of hepatization. The pleura was covered with a grayish sand paper like exudate. In certain areas this was distinctly membranous but for the greater part it was plastic. The parietal pleura was similarly affected. The left lung was partially collapsed and hyperaemic but no areas of consolidation. The pleura was covered with a very thin, pasty exudate.

Bacteriologic examination.—Several tubes of agar were inoculated at the post-mortem from the exudate over the lungs and from the liver, spleen and kidney. On the second day following, plate cultures were made from the exudate, liver and kidney, which were brought to the laboratory in sterilized jars.

The cultures made both at the post-mortem and in the laboratory contained two species of bacteria, namely, the swine-plague bacillus and the large bacillus found associated with the hog-cholera bacillus in pig No. 1.

In the tube cultures this organism seemed, on account of its much more vigorous growth, to predominate. In the plate cultures from the exudate, however, only a few colonies appeared, while those of the swine-plague bacillus were very numerous. Plate cultures were made and rabbits were inoculated from the cultures obtained from the liver, spleen and kidneys. These failed to reveal the presence of any hog-cholera bacteria. The swine-plague bacillus appeared in each case. Rabbits were inoculated with the contaminating bacillus with negative results.

A rabbit, inoculated subcutaneously with an emulsion of the lung prepared by grinding it in a mortar with bouillon, died in 36 hours and its organs contained innumerable swine-plague bacteria. Pure cultures of this organism were obtained from the blood.

Pig No. 3.— This pig had died the day before and had been buried. It was dug up for examination. Black and white pig, weight about 60 pounds. There was no discoloration of the skin; the liver, spleen and kidneys resembled those in pig No. 2. The serous coat of the intestines was thickly sprinkled with punctiform hemorrhages. The mucosa was deeply reddened in certain areas. The lymphatic glands slightly swollen and oedematous. The cephalic lobes of both lungs were collapsed. Otherwise the thoracic organs were normal in appearance. Cultures were made from the spleen and liver. These contained hog-cholera bacteria in impure cultures. No swine-plague bacteria were found.

Pig No. 4.— This pig had been dead and buried for 24 hours. It was about the size of pig No. 2. The examination showed lesions resembling closely those of pig No. 2, but post-mortem changes had discolored parts to such an extent that details were precluded. There was no consolidation of the lungs or ulcers in the intestines. Cultures were not made.

Pig No. 5.—(Pigs Nos. 5 and 6 were received at the laboratory June 5th, they having been sent by express for the purpose of examination). This pig was found dead June 4th. White, male, weight about 12 pounds. It was considerably decomposed. There was no consolidation of the lung tissue. The liver, spleen and kidneys were not enlarged. In the caecum, upper and transverse portion of the colon, the mucous membrane was thickened and necrotic. The mesenteric glands were enlarged. Cultures were made in agar and bouillon and a rabbit inoculated from the intestinal lesions. A portion of the intestine was thoroughly washed in boiled water, the superficial necrosis was scraped away. Bits of tissue from the base of the necrotic mass were obtained for making the inoculations. The cultures revealed the presence of *Bacillus coli communis*, and the bacillus of hog-cholera. The rabbit died on the eighth day with lesions characteristic of those produced by hog-cholera bacteria and from the blood pure cultures of the hog-cholera bacillus were obtained.

Pig No. 6.— This pig was about the same size as pig No. 5. It was killed in what was thought the last stages of the disease on the morning of June fourth. It was slightly affected from decomposition. The liver was firm. The spleen slightly enlarged and the kidneys sprinkled with

punctiform hemorrhages. In the caecum and colon there were a few follicular ulcers. The lungs appeared to be normal. Agar and bouillon cultures were made from the liver, kidneys and follicles. The latter developed impure cultures of *Bacillus coli communis* but the bacillus of hog-cholera was not isolated. Rabbits inoculated with large quantities of the cultures remained well.

At the time of my visit the disease had spread to several of the pens and consequently a large number of the animals had been exposed. Of these, 54 are reported by Dr. Allison to have died subsequently; but of the 54, 39 were small pigs. In nearly all of the cases which developed after June sixth, the animals were sick from 5 to 15 days. The total loss up to June twentieth was 5 breeding sows, 31 shoats and 39 small pigs. The results of the examination of the six pigs show that the disease was a mixed infection of hog cholera and swine plague. Pig No. 1 furnishes a good illustration of the acute type of hog cholera and in pig No. 5 is an illustration of the chronic form. In pig No. 2 we had a case of apparently uncomplicated swine plague, in which the lesions were restricted to the plural membranes. It is unfortunate that more of the animals could not have been examined but the facts elicited were sufficient to warrant the diagnosis. Such mixed outbreaks are not uncommon as shown by the investigations of the Bureau of Animal Industry and those of Drs. Welch and Clements. It appears from their reports that the two diseases frequently coexist in the same animal. Although the loss was in itself heavy, it will be seen that a trifle less than 50 per cent. of the animals in the herd died. This is a low mortality for epizoötics of either of these diseases. The success attained in checking the disease is attributable to the great care exercised in isolation and disinfection. As already stated the disease had become quite well disseminated before its infectious nature was determined.

This outbreak is of much interest from the fact that the channel through which the hog cholera virus gained entrance to the herd has not been found. Sporadic cases of swine plague not infrequently occur from which the specific bacillus is obtained, but as yet we do not know of hog cholera appearing in such a

manner. The animals in this herd were kept under the most favorable conditions, respecting general care, ventilation, and cleanliness. The food was carefully prepared and wholesome. Hog cholera had not appeared in the vicinity and animals had not been purchased since the fall before, and the herds from which they came had not been affected. While the source is not known, the facts are suggestive in pointing out the necessity for further investigations into the normal habitat and distribution of hog cholera bacteria.

Miscellaneous.—In addition to the above I have visited several localities where hog cholera or swine plague was reported to be raging. Those places visited, at the request of the Commissioner of Agriculture, were at Schoharie, Albany, Batavia and Mansville.

At Schoharie the disease had disappeared, but the history and description of the lesions, as given by Dr. Marsh, who made a few post-mortems, indicate that it was swine plague. There was also some evidence that it had been contracted from animals at a county fair, where these had been taken. Later a few more pigs were attacked, but the disease was reported not to have spread beyond this farm. At Albany the disease had likewise disappeared. At Batavia a few hogs were found suffering from slight paralysis, but not sufficiently so to warrant their slaughter for examination. There had been considerable loss among the hogs on a few farms. The origin of the outbreak was traced to a boar, which had been bought by Mr. W., and which had been at the State Fair. The disease was said to have spread from this animal. Later, Mr. W. sent us the lungs, liver and spleen of two of the hogs which died. A careful bacteriologic examination was made, but the specific bacteria of hog cholera or swine plague could not be found.

At Mansville, where I went in company with Inspector Quigley, was found a most deplorable condition. In the basement of a barn, filthy beyond description, were about 40 hogs, old and young, actually starving. Besides these there were about 15 cows, in a similar condition. The animals were emaciated,

standing in filth, with no bedding and an exceedingly small allowance of food. Already several hogs had died and a few had been sold. The conditions found were reported to the local health officer, and to the Society for the Prevention of Cruelty to Animals. However, the owner of this herd had appealed to the Commissioner of Agriculture for assistance in eradicating the disease, with the hope that the Department would pay for and destroy the animals.

In July, Dr. J. A. McCrank, of Plattsburgh, sent to this laboratory two pigs from a herd of about 40, nearly all of which had died of an epizoötic disease. These proved to be suffering from hog cholera, as demonstrated by post-mortem examination. It should be stated that in other herds Dr. McCrank found the cause of death to be the use of swill (dishwater) containing strong alkali from powdered soaps.

Dr. W. H. Kelly, of Albany, who has investigated a number of outbreaks of reported infectious swine disease, has sent us for diagnosis during the year material from no less than seven outbreaks in which he was unable to find characteristic lesions and in which a positive diagnosis could not be made without the aid of a bacteriologic examination. With two exceptions the cultures made and animals inoculated from this material failed to reveal the presence of any pathogenic bacteria. One or more specimens of a similar nature have been received from a number of veterinarians for examination and diagnosis. It is a significant fact, however, that very few of these appeared to have come from animals which died from a bacterial disease. The results of the examination of this material suggests the need of more thorough and more extended investigations into the nature of these epizoötics. In order that one may speak positively concerning the nature of these outbreaks, it is necessary to have a careful examination made of a considerable number of the animals which die in each epizoötic. The best interests of the live-stock industry of the State require that these epizoötics and enzoötics should be accurately diagnosed and the methods best adapted for their eradication rigidly enforced.

IV.

A DESCRIPTION OF THE BACILLI OF HOG CHOLERA AND SWINE PLAGUE.

The specific organisms of these diseases have already been carefully and fully described. There are perhaps no other two species of pathogenic bacteria concerning which there has been more confusion than the bacilli of hog cholera and swine plague. While they are distinct species, widely separated by their morphologic characters and biochemic properties, they are frequently mistaken the one for the other. There is still some uncertainty manifested concerning the identity of the bacteria of these diseases with those of certain swine affections found in Europe. It has already been pointed out that the American hog cholera, the English swine fever and Danish swine pest are identical. The American swine plague and the German Schweineseuche are believed to be the same. This conclusion is based upon the results of a number of special bacteriologic investigations which have been carried out in both this country and in Europe. As many requests are being received for descriptions of the hog-cholera and swine-plague bacteria, and also as there are some swine raisers in this State whose experience has caused them to feel that the diseases we call hog cholera and swine plague are different from those described in the reports of the Bureau of Animal Industry, it has seemed desirable to append a description of these bacteria, based upon a careful study of the cultures obtained from swine in this State. It has been impossible, in the time at our disposal, to carry out extended investigations into the biochemic or pathogenic properties of these forms beyond the limits necessary for diagnosis. As was expected, the organisms studied have proved to be identical with those described from outbreaks in other parts of the country. It is important, however, for those who find slight discrepancies to remember that both the morbid anatomy and the bacteria of these diseases are subject to certain variations. These variations will be referred to in later paragraphs.

Bacillus cholerae suis (Bacillus of Hog Cholera).

Morphology.—A rod-shaped organism varying in size according to the medium in which it has developed. From agar cultures it is from 1.2 to 1.8 microns long and from .5 to .8 microns broad. The ends are rounded. Spores have not been observed. It is actively motile and a variable number, but usually from 3 to 5 flagella have been demontrated.* The length of the flagella also varies. The average seems to be about 7 microns** although filaments 55 microns with an average length of 35 to 40 microns are reported.† It stains readily with the aniline dyes. Preparations made from cultures usually stain uniformly; while in the preparation made from the tissue of inoculated animals there is frequently exhibited a light center with a deeply stained periphery.

Cultural characters and biochemic properties.— This bacillus is grown readily on all of the ordinary media used in bacteriologic work at a temperature of 30 to 38° C.

Agar.— On the surface of inclined agar after 24 hours at a temperature of 37° C. a grayish, glistening nonviscid growth appears. When isolated the colonies are nearly round, convex .5 to 2.0 mm. in diameter. The edges are sharply defined, and even. In stab cultures a grayish growth develops along the needle track with a more vigorous growth on the surface about the needle puncture. The growth reaches its maximum in about 48 hours.

Gelatin.— In this medium the growth is moderately feeble, the colonies appearing as grayish dots. When magnified they are finely granular and of a yellowish tint. The quantity and form of growth depends considerably upon the reaction of the gelatin. If decidedly alkaline there is often a tendency for the growth to spread. There is no softening or liquefaction of the medium.

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* Moore, Wilder Quarter-Century Book, 1893, p. 355.

** A micron is 1-1000 of a millimeter, or 1-25000 of an inch. It is the unit for microscopic measurements.

† Ferrier, Archives de Med. Exper. et d'anat. Patholog. VIII, (1895), p. 58.

Potato.— The growth on potato takes the form of a very thin glistening layer. It is usually of a faintly yellowish color but this is subject to variation on different potatoes. If the reaction is strongly acid no growth appears.

Bouillon.— In alkaline bouillon it imparts in 24 hours a uniformly cloudy appearance to the liquid. Ordinarily there is no membrane on the surface. After some days' standing the growth begins to settle, forming a grayish, friable sediment. If the bouillon contains muscle sugar the reaction will be changed to acid, in from 24 to 48 hours, due to the fermentation of the sugar. Later, however, the liquid will become strongly alkaline, unless there was too much muscle sugar. In acid bouillon the growth is less vigorous. It grows better in a bouillon containing peptone than in a simple beef broth.

Milk.— When the milk is acid in the beginning it gradually becomes alkaline. There is no precipitation or coagulation of the casein. After standing for from two to three weeks in an incubator a gradually developing opalesence of the milk can be observed. Later it becomes clear, then light brownish in color. If allowed to stand longer in the incubator the volume of the culture shrinks by evaporation and the opalescent liquid becomes quite thick and dark-colored but not viscid. When the opalesence appears the milk is strongly alkaline. The process seems to be a form of saponification of the fat globules due to the presence of the alkali produced by the bacteria.

Dunham's solution.— In this solution the growth is quite feeble. Ordinarily no indol reaction is obtained. (The writer has observed a marked indol reaction in two cultures of the hog cholera bacillus.)

Gas production.— In peptonized bouillon containing 1 per cent. dextrose, gas appears within 24 hours and continues to form for from three to five days. During the first day from one-fourth to one-half of the total quantity is produced. By the end of the second day the gas formation is nearly at an end. The total amount which collects in the closed branch of the fermentation tube is equivalent to about one-half of the capacity of this branch.

The gas set free is composed of CO_2 and an explosive gas which consists largely of H. The ratio of CO to H in the fermentation tube is approximately as 1 to 2. The reaction of the liquid becomes strongly acid, which condition checks the multiplication of the bacteria.

Gas is not produced in bouillon containing lactose or saccharose. These sugars are not fermented. Alkaline cultures containing them become more strongly alkaline as the growth continues.

Thermal reactions.—This organism grows very feebly at a temperature of 20° C. It will not thrive at a temperature above 43° C. It is destroyed when exposed in moist heat at 58° C. for 10 minutes.

Disinfectants.—This organism is destroyed after an exposure for 10 minutes or less in the following solutions:

Carbolic acid, 1 per cent.

Hydrochloric acid, 1-5 of 1 per cent.

Sulphuric acid, 1-20 of 1 per cent.

Sulphate of copper, 1-4 of 1 per cent.

Formalin, 1 to 2,000.

Trikresol, 1-2 of 1 per cent.

Lime is also a good disinfectant when used in preparations containing about 1 per cent. CaO.

Drying.—This bacillus resists drying for a variable length of time, according to the amount of protection it has. In a drop of a bouillon culture dried on a cover-glass and kept under bell jars, the vitality is retained for 5 to 8 days. In bits of animal tissue containing the bacilli, the vitality is retained for from 20 to 40 days, according to the quantity of tissue taken.

Pathogenesis.— Subcutaneous injections of from 1 to 3 c. c. rarely produce fatal results in swine. An intravenous inoculation of 5 c. c. usually produces a septicaemia. With smaller doses the "button ulcers," characteristic of hog cholera, have been produced (Welch). By feeding pigs with pure bouillon cultures the intestinal lesions, typical of hog cholera, have also been obtained (Smith).

Rabbits inoculated subcutaneously with 0.1 c. c. of a bouillon culture die in from 5 to 8 days. The essential lesions consist of necrotic foci in the liver and a very much enlarged and dark-colored spleen. Guinea-pigs are affected similarly to rabbits, but death does not usually occur until from 7 to 12 days. Pure cultures of the bacillus can be obtained from the blood, liver or spleen of the inoculated animals.

While the above description applies to the form most frequently encountered, the existence of varieties must be accepted. In 1894 Dr. Theobald Smith* called attention to several varieties of this species. On account of the significance of these forms, his tabulated description of them is inserted.

* Bulletin No. 6, Bureau of Animal Industry, United States Department of Agriculture, 1897.

Hog Cholera Group of Bacteries (Smith).

Variety or species.	Original source.	Morphology.	Motility.	Surface colonies on gelatine plates.	Bouillon cultures.	General character of growth.	Pathogenic Power with Reference to Rabbits.	
							Degree as expressed in numbers.	Character.
B. cholerœ suis α*..	Swine	Involution forms usually absent.	Active.....	Small, round, slightly convex.	Moderately clouded.	Only slightly vigorous.	1	Necrotic foci in liver.
B. cholerœ suis b....	Swine	Somewhat longer forms in bouillon membrane.	Active.....	Large; spreading like *b. coli.*	Surface membrane; growth turbid.	Vigorous; requires more alkali.	2	Necrotic foci in liver.
B. cholerœ suis c....	Swine	Involution forms common; slightly larger than *a.*	Active.....	Small, delicate colonies, resembling *b. typhi abdominalis.*	Turbid..	Vigorous	Very feeble.	Like *b. coli.*
B cholerœ suis d....	Swine	A trifle plumper than *a.*	Active.....	Like *a*.....	Turbid; bacilli in clumps in early cultures.	Fairly vigorous.	4	Same as *a.*
B. cholerœ suis e	Swine	Like *a*.....	Active.....	Like *c*.....	Like *a*.....	Fairly vigorous; agar growth viscid.	1	Same as *a.*
B. cholerœ suis f....	Swine	Slightly larger than *a* ...	Active.....	Like *a*, but larger ...	Turbid	Vigorous.....	3	No liver necrosis; suppurative changes in Peyer's patches, etc.
B. cholerœ suis g....	Swine	Like *a*.....	No motility	Same as *a*.....	Clouded.....	Like *a*.....	1	More speedily fatal than *a.*
Bacillus of abortion in mares	Vagina of mare.	Like *a*.....	Motile	Same as *a* or nearly so.	Clouded.....	Like *a*.....	4	Necrosis in liver and spleen.
Swine pest.....	(Denmark).	Like *a*.....	Motile.....	Same as *a* or nearly so.	Clouded.....	Like *a*.....	.....	Same as *a.*
B. typhi murium Lœffler.	White mice (1890).	Plumper than *a*.....	Motile.....	Spreading like *b*.....	Turbid	Vigorous	4	No necrosis in liver.
B. enteritidis Gærtner.	Cow	Rather slender forms; variable.	Motile.....	Like *a*.....	Turbid	Vigorous	4	No necrosis in liver.

*In the text the corresponding letters in the Greek alphabet are used to designate the varieties.

A Table Illustrating the Formation of Gas in Dextrose Bouillon (Smith).

Bacilli belonging to the hog cholera group cultivated at 98 degrees F. in bouillon containing one-fourth per cent peptone, two per cent dextrose, and one half per cent sodium chloride.*

CULTURE.	Quantity of Gas at 98 Deg. F. Set Free After					Total 70–80 degs. F.	CO_2.	Explosive remainder (H).	Reaction.
	One day.	Two days.	Three days.	Four days.	Five days.				
a	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Nebraska, 1889	17.4	41.7	54.8	60.0	57.4	54.8	38.0	62.0	Acid.
District of Columbia, 1889	24.0	48.0	54.4	56.0	54.4	50.4	30.0	70.0	do.
b									
Nebraska, 1886	32.5	35.8	37.5	40.0	37.5	36.6	34.0	66.0	do.
c									
New Jersey, 1890	33.3	48.3	51.6	56.6	55.0	50.8	37.7	62.3	do.
d									
New Jersey, 1890	40.8	50.0	53.6	56.0	53.6	50.4	38.0	62.0	do.
e									
Virginia, 1890	34.7	51.3	55.6	58.2	57.4	53.9	37.0	63.0	do.
f									
Maryland, 1889	43.4	48.6	50.4	52.1	50.4	46.9	37.0	63.0	do.
Virginia, 1889	45.0	58.2	58.2	58.2	55.8	52.4	36.0	64.0	do.
g									
Non-motile bacillus	.....	.....	.....	33.0	37.5	36.6	26 0	74.0	do.
Abortion in mare	12.1	50.0	58.2	61.7	59.1	54.7	36.5	63.5	do.
Swine pest	32.8	43.4	45.0	45.0	45.0	41.8	33.3	66.6	do.
Mouse typhus	.....	46.4	48 0	....	50.0	50.0	35.0	65.0	do.
B. enteritidis	.....	48.8	52.0	.....	48.8	48.8	29.5	70.5	do.

* There is no noticeable difference between 1 and 2 per cent. dextrose bouillon.

On account of the wide differences which exist between forms recognized as varieties of the hog-cholera bacillus, it becomes difficult to fix the common characters which circumscribe the hog-cholera group of bacteria. A careful study of certain of these varieties will show that they possess properties not dissimilar from certain of those attributed to extreme varieties of *Bacillus coli communis*. The pathogenesis is usually considered of first importance, but here we find forms possessed of as little virulence as certain varieties of the colon group. The closer study of bacteria is directing attention not only to the significance of a fixed pathogenesis, but also to other characters, for it is believed by some writers that the disease-producing power of bacteria is the last character acquired and evidently it is the most variable and most readily lost. It is at the present time difficult, in fact impossible, to point out any limiting characters or properties for this group. Dr. Theobald Smith suggests "that all bacteria whose size approximates that of this group, which do not liquefy gelatin and whose fermentation properties are the same as those described for the group, should be ranged under it." The study of these bacteria has opened up important fields for investigation and thrown out many valuable suggestions for future inquiries concerning the important problems involved in the etiology of infectious diseases.

Bacillus Septicaemiae Hemorrhagicae. Hüppe.

(BACILLUS OF SWINE PLAGUE.)

Morphology.—A non-motile, rod-shaped organism varying from 0.8 to 2.0 microns in length and from 0.1 to 1.2 microns in breadth. The ends are oval, and the shorter forms resemble micrococci. The size depends upon the medium and the stage of development of the individual bacteria. A capsule has not been demonstrated, although often there appears to be one in preparations made directly from tissues. It is not observed in cultures. Spores have not been seen. Involution forms are not uncommon in old cultures. They are especially numerous in the organs of a rabbit when it is allowed to lie for some hours after death, before it

is examined. It exhibits, when stained in cover-glass preparations made directly from animal tissues, a light center with deeply stained extremities (polar stain). In preparations made directly from cultures this character is much less marked. It stains readily with the basic aniline dyes. It does not retain the coloring matter when stained after Gram's method.

Cultural and biochemic properties.—This organism is less hardy than the bacillus of hog cholera, and on certain of the media used it grows very feebly or not at all. It requires a temperature of about 37° C. although it develops very slowly at the room temperature.

Agar.—The growth on this medium is not vigorous. It is of a neutral grayish color, with a glistening, moist appearing surface. It is slightly viscid and adheres to the agar surface. Isolated colonies vary from 1 to 2 mm. in diameter, nearly round, convex, with smooth and sharply-defined margins. The condensation water becomes faintly clouded with a grayish sediment which becomes viscid. Within the agar the colonies appear as minute grayish dots. In agar, especially in plates (Petri dishes), it emits a peculiar disagreeable pungent odor.

Gelatin.—Ordinarily it does not grow in gelatin. (Dr. Theobald Smith found that certain cultures grew in this medium.)

Potato.—It does not grow on potato.

Bouillon.—Alkaline peptonized bouillon becomes uniformly clouded in 24 hours when kept at a temperature of 36° C. Occasionally cultures are obtained in which the growth appears in the form of flocculent masses, but usually after a few generations these disappear and the liquid becomes uniformly cloudy. If the bouillon contains any dextrose or muscle sugar, its reaction becomes acid in 24 to 48 hours, owing to the fermentation of the carbohydrate. With the virulent cultures the liquid clears within a few days. The small amount of grayish sediment becomes viscid after some days, and upon agitation it is forced up, appearing as a somewhat twisted tenacious cone, with its apex at or near the surface of the liquid. Frequently a thin, grayish, somewhat viscid band composed of bacteria is found on the sides of the tube

at the surface of the liquid. It will not grow in acid bouillon. If the bouillon contains from 1 to 2 per cent. glucose, the growth is slightly more vigorous.

Effect on sugars.—In the fermentation tube, alkaline bouillon containing sugars become uniformly clouded in both branches. Gas is not produced. In bouillon containing dextrose and saccharose the reaction becomes strongly acid in 24 hours, but the reaction of alkaline bouillon containing lactose is not changed.

Milk.—Milk inoculated with this organism remains unchanged in appearance for several weeks. When boiled, after this period, the casein is not coagulated.

Indol.—This organism grows feebly in Dunham's solution; some cultures have given a decided indol reaction, but others have not. The production of indol is reported to be one of the properties of the German swine plague. Smith* obtained only a trace of indol in one out of four cultures of swine-plague bacteria.

Phenol.—This was found by Lewandowski's† method in all of the cultures tested by Smith (*l. c.*). I have failed to obtain the reaction in a few cultures, but usually it appears.

Thermal death point.— This organism is destroyed in bouillon at 58° C. in ten minutes. A temperature of 56° C. for this time did not destroy its vitality.

Effect of drying.— This bacillus can not stand drying. The bacilli in a drop of bouillon dried on a cover-glass and kept at the room temperature are destroyed in 24 to 36 hours. In similar preparations made from agar cultures they resist drying from five to eight days. The difference in the time between the two cultures is probably due to the thicker layer in case of the agar preparations.

Persistence of vitality in water and soil.— Experiments to determine the length of time this organism will live in water and in the soil show that it is destroyed in water in test tubes in from nine to eleven days. In the soil it was not found after eight days. Dr. Smith states that it is destroyed in the soil after four days.

* Special report on swine plague, 1891, p. 89.

† Deutche med. Wochenschrift, 1890, s, 1186.

Power to resist disinfectants.— The bacillus of swine plague is very sensitive to the action of disinfectants. A large number of these agents have been tested. The following are among the more important:

Commercial sulphuric acid, $\frac{1}{8}$ per cent. kills in 30 minutes.
Commercial sulphuric acid, $\frac{1}{4}$ per cent. kills in 10 minutes.
Lime, lime water kills in 1 minute.
Lime, 0.015 per cent. kills in 30 minutes.
Carbolic acid, $\frac{1}{2}$ per cent. kills in 60 minutes.
Carbolic acid, 1 per cent. kills in 5 minutes.
Carbolic acid, 2 per cent. kills in 1 minute.
Formalin, solution 1-2000 kills in 5 minutes.
Trikresole, $\frac{1}{2}$ per cent. kills in 5 minutes.

Pathogenesis.— This organism is pathogenic for rabbits, guinea pigs and mice among the smaller experimental animals and for swine. With the virulent form rabbits inoculated either subcutaneously or in the vein with very small, 0.001 c. c. doses, die of septicaemia in from 16 to 24 hours. Guinea pigs are slightly less susceptible. When inoculated subcutaneously with 0.1 to 0.2 c. c. of a bouillon culture, they die in from 30 to 72 hours. Mice succumb in about 24 hours when inoculated with a drop of the culture. Pigs inoculated intravenously usually die from acute septicaemia in from 18 to 36 hours. If they live longer there may be decided lung lesions. (See report on swine plague, Smith.)

Distribution of swine plague bacteria in nature.— Dr. Smith discovered in the study of isolated or sporadic cases of pneumonia that the swine plague bacillus was present although the source of infection could not be found. Following out the method introduced by Sternberg in 1881, he inoculated rabbits with the secretions from the upper air passages of healthy swine and curiously enough found that over 40 per cent. of healthy swine harbor this organism. These observations were extended to other animals with the result that this species was found to be quite widely distributed in the upper air passages of the domesticated

animals. Later the writer* made a careful study of this subject. From the results obtained it was shown that a bacillus not distinguishable from the swine plague bacillus is present in 48 per cent. of healthy pigs, 80 per cent. of cattle, 50 per cent. of sheep, 16 per cent. of horses, 30 per cent. of dogs and 90 per cent. of cats. These percentages are necessarily based upon a comparatively small number of examinations. In the sheep the bacteria were possessed of a low degree of virulence, while those from the various cats possessed a very high degree of virulence, requiring but from 18 to 24 hours to kill rabbits.

It should be observed that so far as cultural characters and pathogenesis for rabbits are concerned the bacillus of swine plague is not distinguishable from the bacillus of rabbit septicaemia (Koch), of fowl cholera (Pasteur) and of the German *Wildseuche*. There is little definite knowledge concerning their distribution in nature outside of the living animal body. On this point there is special need of further investigation.

For convenience in comparing the properties of these two species of bacteria, and in order that they may be more easily contrasted, I have arranged them in like order in parallel columns.

Bacillus of Hog Cholera.	Bacillus of Swine Plague.
1. Rod-shaped organism with ends rounded, 1.2 to 2.0 microns in length, 0.5 to 0.8 micron in width. The size varies according to the stage of growth and division, and the culture media.	1. Elongated oval organism 0.8 to 1.5 micron in length, 0.6 to 0.8 micron in thickness. The size varies according to the stage of growth and division, and the culture media.
2. From cultures it stains entirely. In tissues it usually stains around the periphery with darker extremities leaving a light centre.	2. From old cultures it usually stains entirely. When in process of division as found in the organs of freshly dead rabbits the extremities stain leaving an unstained central band, "polar stain."
3. Actively motile in liquids.	3. Not motile in liquids.
4. From 3 to 9 flagella are demonstrable.	4. No flagella have been found.
5. Vigorous growth in alkaline nutrient liquids. Less vigorous if liquids are acid in reaction.	5. Growth moderate or feeble in alkaline nutrient liquids. No growth if liquids are acid.

* Bulletin No. 3, Bureau of Animal Industry, United States Department of Agriculture, 1893, p. 38.

6. Moderate growth on potato. (Varies according to reaction.)

7. Distinct growth on gelatin.

8. Saponifies milk in from 3 to 4 weeks.

9. Ferments dextrose with the formation of acids and gas.

10. Does not ferment lactose. Bouillon containing it becomes strongly alkaline. No gas.

11. Does not ferment saccharose. Bouillon containing it becomes strongly alkaline. No gas.

12. Destroyed by moist heat at 58 degrees C. in 15 minutes.

13. Dies in water in from 2 to 4 months.

14. It dies in the soil in from 2 to 3 months.

15. Rabbits injected subcutaneously with 0.1 c.c. of a bouillon culture of a virulent bacillus will die in from 5 to 7 days. Enlarged spleen, necrotic foci in liver.

16. Rabbits inoculated with culture of an attenuated variety live from 10 to 20 days or recover. The lesions are enlarged spleen, and infiltration of the follicles in Peyer's patches.

17. In guinea-pigs the lesions are practically the same as in rabbits. Death occurs in from 7 to 12 days.

18. Pigs are not usually affected by subcutaneous injection of small quantities of culture. If the pigs are killed within 1 to 3 weeks the bacilli are found in the local lesion and certain of the lymphatic glands. Fatal results are reported in a few cases by these injections.

19. Feeding cultures to pigs which have fasted for 24 hours produces extensive intestinal lesions with fatal results.

20. Intravenous inoculation into pigs causes either an acute septicaemia or a chronic form of the disease in which are produced quite typical round, firm, elevated ulcers.

6. No growth on potato.

7. Feeble or no growth on gelatin.

8. Produces no apparent change in milk.

9. Ferments dextrose with the formation of acids but no gas.

10. Does not ferment lactose. No gas.

11. Ferments saccharose with the formation of acids. No gas.

12. Destroyed by moist heat at 58 degrees C. in 7 minutes.

13. Dies in water in from 10 to 15 days.

14. It dies in the soil in from 4 to 6 days.

15. Rabbits injected subcutaneously with 0.01 c. c. of a bouillon culture of a virulent bacillus will die in from 16 to 20 hours. Septicaemia.

16. Rabbits inoculated with a culture of an attenuated variety will live from 4 to 10 days. The lesions are local infiltration of pus cells with pleuritis, pericarditis or peritonitis.

17. Guinea-pigs are slightly less susceptible than rabbits. There is more local reaction. Death occurs in from 1 to 4 days.

18. Pigs are not usually affected by the subcutaneous injection of small quantities of culture. The bacilli are not found except in the local lesion. In a few cases fatal results are reported.

19. Feeding cultures to pigs usually produces no effect.

20. Intravenous inoculation into pigs usually produces a septic form of the disease which kills in from 1 to 2 days. Inoculation into the lungs causes pleuritis, usually accompanied with pneumonia.

DESCRIPTION OF PLATES.

Plate 1. A portion of the caecum of a pig affected with hog cholera. It shows the ulcers on the mucous membrane. The tied small intestine is shown at the right with the ileo-caecal valve. (From the report on hog cholera, Bureau of Animal Industry, United States Department of Agriculture, 1889.)

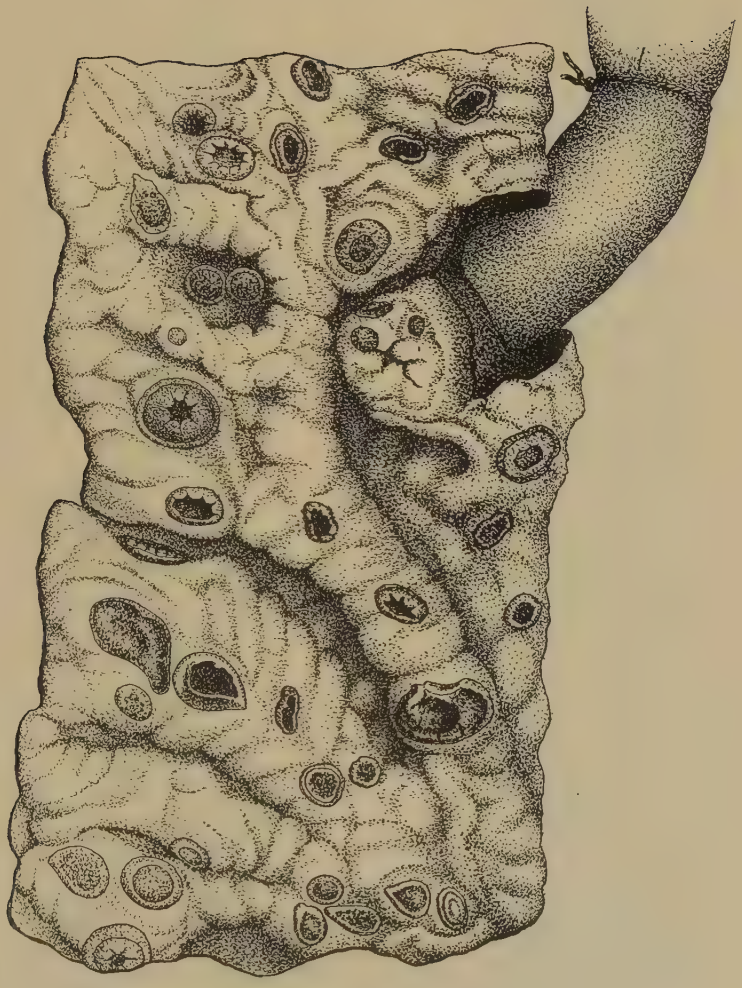
Plate 2. Spleens from two pigs of the same age and weight. (a) Spleen of healthy pig. (b) Spleen from a pig dead from hog cholera. Drawings two-thirds natural size.

Plate 3. Right lung of pig. The stippled portion is usually involved in cases of infectious pneumonia or swine plague, c-cephalic lobe, b-ventral lobe, a-principal lobe. The ventral lobe is usually the seat of the more advanced disease and consequently the first to become hepatized. The cephalic portion of the principal lobe (X) is usually hepatized and the remaining portion deeply reddened.

Plate 4. Hog-cholera bacteria. (1) A drawing from a stained preparation from a bouillon culture four days old. It shows large involution forms. (2) A drawing of a part of the field from a stained cover-glass preparation from the spleen of a rabbit which died from the effects of hog-cholera bacteria. A few of the bacteria show a light center. (3) Hog-cholera bacteria showing flagella. Magnified about 1,000 diameters.

Plate 5. Swine-plague bacteria. (1) Drawing of a part of a cover-glass preparation of swine plague bacteria from a bouillon culture. (2) A drawing from a cover-glass preparation made from the spleen of a rabbit showing the polar stain. (3) A drawing from a similar preparation made from the lung of a pig which died of swine plague. It shows a large number of bacteria, very few of which exhibit the polar stains. The drawings show the bacteria magnified about 1,000 diameters in Figs. 2 and 3 and about 2,000 diameters in Fig. 1.

PLATE I.



ULCERATED CAECUM—HOG CHOLERA.

NORMAL AND DISEASED SPLEENS—HOG CHOLERA.

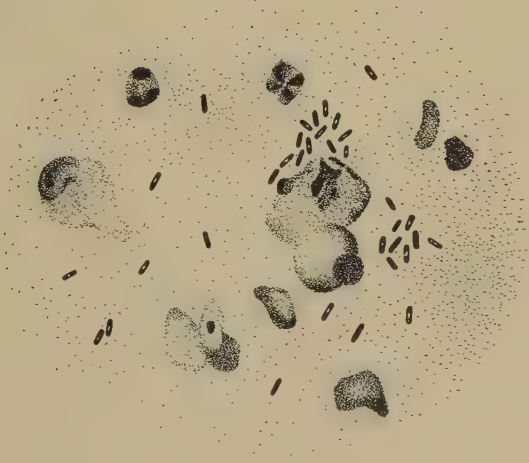
PLATE III.

SWINE PLAGUE LUNG.

PLATE IV.

1

2



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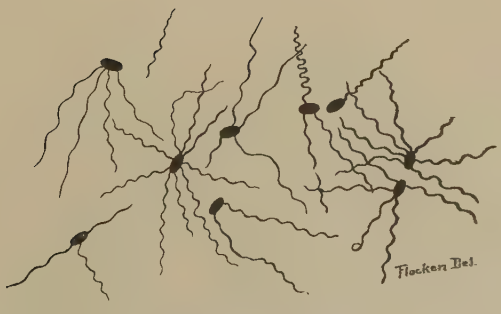

HOG CHOLERA BACTERIA.

PLATE V.

1

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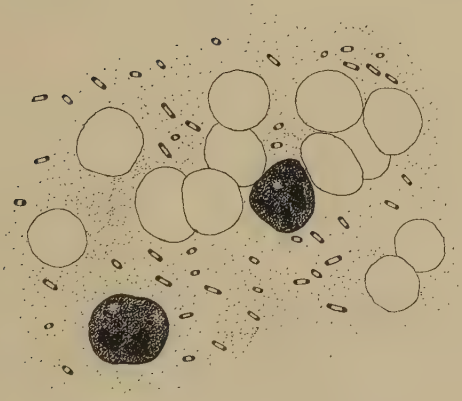

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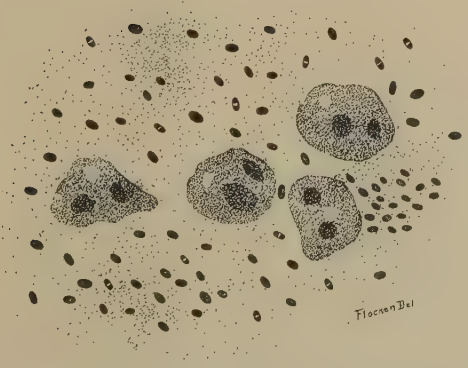

SWINE PLAGUE BACTERIA.

Remarks on Anthrax and Rabies with Special Reference to Outbreaks Recently Investigated.

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I.

During the summer and fall of 1897 one outbreak of anthrax and two of rabies have come to our notice. In addition to these a few specimens of organs from animals supposed to have died of anthrax have been sent to this laboratory for diagnosis, but the examinations have given negative results in all of these cases. In the outbreaks about to be mentioned the investigations were in case of the rabies restricted to making the diagnosis, but with the anthrax Touissant's preventive treatment was tried. On account of the infrequency of the occurrence of these diseases, and the fact that there are still many people who believe that they do not exist in this country to such an extent as to render them of any practical importance, it has seemed desirable to call attention not only to the existence of these maladies but also the methods of diagnosing and preventing them. It is necessary in order to secure the highest protection for our live stock interests that these maladies should be better understood, for of the infectious diseases common to men and the lower animals these are, next to tuberculosis, most deserving of attention. The significance of these affections may be more fully appreciated from the fact that anthrax has already been reported in fifteen of the States, and rabies is annually causing hundreds of deaths among domesticated animals as well as destroying many human beings.

It is, therefore, incumbent upon every citizen to take all necessary precautions to prevent the entrance of these maladies and to use all possible means to eradicate them if, perchance, they should make their appearance in the future.

An Outbreak of Anthrax Near Elmira, with Results Obtained by Touissant's Preventive Treatment.

At the request of the Hon. C. A. Wieting, Commissioner of Agriculture, I visited Elmira September 24, 1897, to make an investigation into the nature of a destructive disease which had appeared among the cattle on a farm in that vicinity. Three of the farm hands were also affected, but eventually they recovered. I was accompanied to the infected herd by Dr. Wadsworth, of Cobleskill, and Doctors Ross and Jeffery, of Elmira. At this time the disease in the attendants had been diagnosed by Dr. Ross as malignant pustule, and on the basis of this diagnosis he had assumed that the disease among the cattle was anthrax and had brought it to the attention of the Commissioner of Agriculture.

It was learned that on September 8th, a cow which had been kept on another place was found sick and brought home. Later she died, and in skinning this animal the attendants were infected. The disease first appeared in the men September 11th. September 16th a second cow died very suddenly, September 21st a third cow died and on the 23d three more were buried. At the time of our visit one cow was in a state of collapse. Although the diagnosis of malignant pustule in the attendants seemed to be correct, a positive diagnosis of the disease in the cattle was of much importance. To this end the sick cow was killed and carefully examined.

Cow No. 1.— Large, well developed cow in good condition, temperature 98 degrees F. Unable to walk, killed by a blow on the head and by bleeding. Two liters of the blood were collected in sterile jars. Blood not abnormally dark or thick, the spleen seemed to be slightly darker than normal. On the omentum were numerous slightly congested tufts. Otherwise the abdominal organs appeared to be normal. There was a small

quantity of clear urine in the bladder. The heart and lungs appeared to be normal. Several tubes of agar and gelatin were inoculated from the heart blood, spleen, liver and kidneys. Pieces of these organs were placed in sterile jars and brought to the laboratory where they were carefully examined.

The post-mortem examination left serious doubts in the minds of all present concerning the nature of the disease. The absence of practically all of the lesions described as being typical of anthrax gave ample reason for the manifest doubt. The autopsy was made about noon and later in the afternoon the tissues were examined microscopically in the laboratory. Stained cover-glass preparations from the spleen showed large numbers of anthrax bacilli. In similar preparations made from the liver, kidneys, and blood there was a less number of the organisms. On the following day all of the inoculated tubes contained apparently pure cultures of the anthrax bacillus.

On the second day the growth in the gelatin tubes appeared. They were all pure cultures of *bacillus anthracis.* The bacteriologic examination, therefore, proved the existence of anthrax. Without this examination the positive diagnosis in this animal could not have been made.

September 26th, I again visited the herd and found that a Jersey cow had been taken sick the evening before and had died just before my arrival. Three others were found to be affected as indicated by the temperatures which were 105, 105.7 and 107.7° F. respectively. The dead animal was carefully examined.

Cow No. 2.—Small Jersey cow. Blood was oozing from the anus. The abdominal cavity contained a considerable quantity of blood-stained serum. The blood was very dark, the spleen was enormously enlarged, very dark colored, soft, and the capsule contained ecchymoses. Upon section the blood and pulp flowed quite freely. The liver was slightly congested, kidneys deeply reddened and in the bladder there was a small quantity of dark wine colored urine. On the omentum were numerous hyperaemic tufts. The intestines were hyperaemic. There were several ecchymotic areas beneath the pericardium. The lungs were congested. About two liters of the blood were collected from the vena cava. Portions of the spleen and liver were brought to the laboratory where a microscopic examination and cultures were made. These revealed the presence of anthrax bacilli.

About 20 c. c. of milk was taken from each teat in sterile tubes, for examination. The milk from one quarter was slightly blood stained, but from the others it was normal in appearance. Upon microscopic examination the anthrax bacilli were found in the preparations made from the blood-stained milk but they were not discovered in those made from the other specimens. Guinea pigs were inoculated subcutaneously with 2 c. c. of the milk from each teat. They all died of anthrax in from 24 to 72 hours, showing that the bacilli were present in each specimen although not numerous enough, with the one exception, to be easily detected microscopically.

Milk was also collected from one of the cows which was sick and had been for two days. Her temperature, when the milk was taken, was 106.5° F. This was examined microscopically and two guinea pigs were inoculated subcutaneously with 3 c. c. each. No anthrax bacilli were found in the preparations and the guinea pigs remained well. This cow recovered. Another specimen of milk was taken from a cow having a temperature of 105° F. The examination gave negative results. It would seem, from the few examinations made, that the bacilli in the milk from cow No. 2, had gotten into it just before or immediately after death. There are cases reported, however, where the disease has been contracted from drinking the milk of affected cows.

Some difficulty was encountered in the disposal of the dead animals. Those which had died before out visit had been buried and fortunately, with the exception of the first, without being opened. It was necessary to examine post-mortem the last two for the purpose of diagnosis. Unfortunately it was not practicable to burn the animals, and consequently they were buried deeply and the bodies covered with a liberal quantity of quick lime. The owners were directed to cover the surface over all of the graves with a thick layer of lime and to put a fence around them, thus preventing other animals from grazing over them.

The importance of this outbreak does not stop with the losses sustained in this herd. The fact that the disease was brought on the farm by the cow which contracted it on a neighboring

farm, is significant in showing that the place where the disease was found, is not the only infected spot in the neighborhood. It is rumored that several cows have died, presumably of anthrax, during the fall on a near-by place. It seems that losses are being sustained in that locality from this disease without the owners of the cattle recognizing its true nature. In consequence of this the dead animals are inadequately disposed of and the barns and yards are not disinfected. Unless active measures are taken to destroy the virus in all of these cases, the future promises to see this section so saturated with anthrax that dairying will become practically impossible. However, if such precautions as are known to be effective are taken, it seems to be an easy task to eliminate the disease, although several years may be necessary to accomplish it.

PREVENTIVE TREATMENT.

Up to the time of the first visit, September 24th, seven cows including the one killed for examination at that time had died. There were still twenty animals in the herd. The sick were being separated from the others as soon as they showed signs of disease, but it was evident that the entire herd had been exposed and that the pastures and cattle yards had very probably become quite generally infected. The stables were thoroughly disinfected with sulphuric acid and the yards covered with lime. It was decided, however, to try preventive inoculation according to a modification of the method recommended by Touissant, as this could be applied with little delay, which in this herd seemed to be of great importance. Further, Dr. Law has for several years followed this method with success in several serious outbreaks which have come under his observation.

The method recommended by Touissant is to heat the defibrinated blood from an animal dying, or just dead, from anthrax, for from ten to fifteen minutes at a temperature of from fifty to fifty-five degrees C. Dr. Law has followed the practice of heating the blood to a much higher temperature in order to be sure of the death of all bacilli present. It seemed, how-

ever, that we should be assured by actual cultivation tests that the heated blood was free of all living bacilli or spores before it was injected into healthy animals. Accordingly the blood collected from cow No. 1, was brought to the laboratory, diluted after Dr. Law's method, thoroughly heated in an autoclave, strained and filtered. The filtrate was placed in small flasks and boiled. After cooling a number of tubes of bouillon and agar were inoculated from it. These remained sterile. On the 26th, this preparation of blood was used on all the cattle still living in the herd. The blood preparation was injected subcutaneously in the dose of 4 c. c. in each of the well animals. The injections were repeated and the temperatures taken by Dr. Jeffery, of Elmira, on each of the two following days. The outcome was eminently satisfactory as not one of the animals treated showed a rise of temperature after the injection. The temperatures were again taken October 6th. They were all normal.

As already stated, on the date of injecting the cows we found three sick animals. It was not thought desirable to inject these, as their death seemed to be inevitable, but as the owner thought they would die anyway, he was anxious that they should be included, and his request was granted. The effect of the treatment on the three sick animals was quite surprising. The temperatures at the time of the first injection was 105.7, 106 and 107° F. Two days later they were 102, 101 and 106.6° F. respectively. The temperatures taken subsequently showed that those of the first two remained normal and that of the third gradually subsided, reaching the normal in about two weeks.

The successful results obtained in preventing the spread of the disease in this herd are in accord with those heretofore experienced by Dr. Law. The facts that the cattle were coming down with the disease at the rate of two a day when the treatment was begun, and that the thorough disinfection of the barns was not completed, owing to an accident with the disinfectant, until two days later (September 29th) suggests that the preventive treatment possessed some degree of efficiency. Laboratory experiments on the smaller animals, and also on cattle, are now in

progress by which it is hoped to determine to what extent, if any, the heating of the blood to a higher temperature will affect the efficiency of the original method. We do not feel that the blood heated at the low temperature recommended by Touissant is safe, although it seems to have many adherents in France. If this process can be rendered safe and possessed of the same degree of efficiency that it has appeared to have in this outbreak, it would seem to be more practicable and a much safer prevention than the Pasteur vaccine treatment.

Pasteur's method consists in inoculating the animal with a small quantity of a culture which has been cultivated at a high temperature—42-43° C.—for several days. This deprives the bacilli of their virulence. To strengthen the resistance, the animals are again inoculated with a stronger virus. After the two inoculations they are said to be protected against the most virulent anthrax, but this immunity is of short duration. Chamberland reported in 1894 that a total of 1,988,677 animals had been inoculated in France, and the loss from anthrax had diminished from 10 per cent. in sheep and 5 per cent. in cattle to less than 1 per cent. Cope, in his report to the English Board of Agriculture, regards the conclusions of Chamberland as somewhat fallacious, because in order to prove that the animals inoculated received immunity, it should be shown that they were subsequently exposed to the risks of natural infection. The excellent work which has been done by Neal and Chester, at the Delaware College Experiment Station, has shown the possible efficiency of this method. Of the 331 cows which they vaccinated against anthrax, two died of the disease, giving a death rate of less than 1 per cent., and this in a territory so saturated with the virus that it was practically impossible to keep cattle at all before its use.

A more critical study of the reports on the use of this vaccine shows that while success can not be denied, failures must be admitted. It is reported both in England and Germany that the Pasteur vaccine has not been a marked success. In England, Klein, who tested the vaccine used in that country, found that if the animals did not die from the effect of the vaccine, they did

when exposed to the disease. The German veterinarians and agriculturalists agree that the first vaccine is mild and harmless, but that the second vaccine, even in the hands of experts, is dangerous and often fatal. The fact is reported to have been demonstrated by experiment that the virulence of the attenuated virus is easily restored. Again, it has been shown by the investigations of Chester and Neal, of the Delaware College Agricultural Experiment Station, that a vaccine which succeeded at one time subsequently proved fatal. The vital objection to this method is, that it requires the use of the living bacilli which may become virulent. The scattering of pathogenic organisms, even in an attenuated condition, should, if possible, be avoided. It must be admitted, however, that this method has done great good and helped to rob anthrax of much of its former terror, especially for the farmers of Europe. Notwithstanding, it is highly probable that the spreading of a knowledge of the cause of this disease has also had a great influence in checking its ravages.

In Germany and England the stamping-out system is considered superior to vaccination. According to Crookshank, in England it is regarded as the only reliable means of suppressing the disease. To this end rigid laws have been enacted. In this State steps for its eradication seem infinitely better than the adoption of methods for establishing a tolerance for its existence.

THE CAUSE OF ANTHRAX.

As early as 1849, Pollender called attention to peculiar rod-like bodies in the blood of animals dying of anthrax. In 1863, Davaine published the results of investigations in which he showed that the disease could be produced by inoculating animals with the blood or tissues containing these rod-shaped organisms. Later, Koch isolated the bacilli, cultivated them on artificial media and with these cultures he produced the disease. This established the specific nature of anthrax.

The bacillus of anthrax (*Bacillus anthracis*) is a rod-shaped organism varying in length from one to four microns, but having a quite uniform breadth of about one micron. In a suitable

medium it grows out in long flexible filaments, which combine to form thread-like bundles. When examined, the ends of the rods seem to be square cut. In preparations from animal tissues there appear sometimes to be slight concavities in the ends of the segments when two of them are united. In old cultures spores are formed. These are oval, highly refractive bodies held within the cellular envelope of the filaments, but later they are set free by the dissolution of this membrane. It stains readily with the aniline dyes and also by Gram's method.

The bacillus of anthrax is aerobic. It grows on all of the ordinary culture media at a temperature of from 20 to 38° C. It does best in a neutral or slightly alkaline medium. Its growth is arrested in acid media. In bouillon it develops in ragged somewhat flocculent grayish masses, which are usually held in suspension. In gelatin tube cultures a grayish growth appears along the line of the needle puncture, from which lateral thread-like ramifications extend. The gelatin begins to liquefy on the surface in from two to three days. On agar the colonies are quite characteristic, appearing under the microscope to consist of interlacing filaments. Gas is not formed in bouillon containing sugars. It does not produce indol. The casein in milk is at first coagulated and later digested leaving a clear brownish colored fiuid. It is pathogenic for nearly all of the smaller animals, destroying rabits, guinea pigs and mice in from twenty-four to forty-eight hours. The essential lesions being a local oedema.

In diagnosing this species it is to be differentiated from the groups of bacteria which are represented by the bacilli of malignant oedema and of symptomatic anthrax or *Rauschbrand*. It is also sometimes confounded with a rod-shaped organism usually present in decomposing animal tissues. All of these organisms are anaërobic, and, in their morphologic and biochemic properties, they differ from each other and from the anthrax bacillus. *Bacillus subtilis* has occasionally been taken for the anthrax bacillus but it is readily separated in cultures. It is important, however, to recognize the possibility of an error, if the conditions restrict the examination to the study of but one or two characters or properties.

The bacillus of anthrax itself is not an especially hardy organism, but on the contrary it is easily destroyed by weak disinfectants and it has a low thermal death point. On the other hand its spores are among the most hardy of bacterial life to resist chemical and thermal agents. They resist drying for months or years and often boiling for a half hour or longer does not destroy them. On this account it is very difficult to eliminate the virus from infected pasture lands, especially if they are wet or marshy.

The question is naturally asked, how are these bacteria introduced, where do they come from, and what are the channels through which they are able to pass from one locality to another? These are questions of the first importance in connection with the prevention or eradication of the disease. It should be stated that thus far investigations have failed to reveal any definite knowledge pertaining to the distribution in nature or the origin of the bacillus of anthrax. We are forced, therefore, to conclude that wherever the disease appears its virus has been introduced in some way, at some previous time, although it may have been years in the past.

In fact it has not been difficult in most cases to find a means of entrance. As the spores may remain in the soil in a dormant condition for many years it sometimes happens that the disease does not appear until long after the introduction of the virus. Anthrax has been known to break out among cattle grazing on a field in which were buried many years before the hides from affected animals. Through some means the spores were able to get to the surface and contaminate the grass. Pasteur thought the earth worms were active agents in this work. Koch's investigations tend to disprove this theory. The spores may be introduced through blood or bone fertilizers. The skin, hair, wool, hoofs and horns could if taken from infected animals carry the virus to the place of destination of these articles. When the extent of this traffic is realized, it is easy to understand how anthrax has been brought to this country and why it occasionally appears here and there over a large part of the continent. Many outbreaks, as well as isolated cases, illustrating this common method of dissemination are on record.

II.

Two Outbreaks of Rabies.

On account of the infrequency of rabies there is, as might be expected, much indifference concerning it until an outbreak of greater or less importance actually occurs. When a dog is suspected of being mad it is usually killed and buried without having the true nature of the disease from which it suffered determined. This practice is unfortunate especially if the suspected dog has bitten other animals or men. If the positive diagnosis is made it tends to relieve the anxiety of those concerned. If it is in the affirmative, precautions can be taken by keeping the exposed animals either in confinement or by destroying them at once, and all persons who have been bitten can avail themselves of the Pasteur treatment which has become recognized as a highly effective prevention if taken in time.

This suggests the question, how can a positive diagnosis be made? It is to the investigations of Pasteur, and others following his methods that we are indebted for a method by which the diagnosis of this most dreaded of all diseases can be made. Although rabies is a specific malady its etiological factor has not been isolated, but Pasteur has shown that it is always present in the brain and spinal cord of the affected animal. He has also pointed out the fact that if rabbits or other experimental animals are inoculated beneath the dura with a drop of a suspension of the brain from the rabid dog, they will develop the disease after a certain length of time. This method is now in general use among pathologists for diagnosing rabies. Some workers use guinea pigs but ordinarily rabbits are taken. In the writer's experience the symptoms are more marked in rabbits, than in the guinea pig.

The method as ordinarily followed is this: The brain of the animal supposed to have died of rabies is removed under aseptic precautions and placed in a sterile jar. A small piece of it, usually from the medulla, is ground in a sterile mortar with a few cubic centimeters of sterile water or bouillon until the brain tissue is held in suspension in fine particles. The rabbit is then

etherized, the hair clipped from the forehead, and the skin thoroughly washed with a disinfectant. A longitudinal incision is made in the skin which is held back, a crucial incision is made in the periosteum at one side of the median line, the points turned back, and with a small trephine a disk of bone is removed leaving the dura quite exposed. With the hypodermic syringe, a drop of the brain suspension is easily injected beneath the dura, the periosteum returned and the wound in the skin washed with a disinfectant. The rabbit soon recovers from the anaesthetic. The inoculation wound heals rapidly, and the animal appears to be perfectly happy until the premonitory symptoms develop. This should not occur for at least ten days in cases of street rabies. The first symptoms usually appear in from fourteen to thirty days, occasionally they do not develop for a much longer time. The writer* has observed fifty days to pass before they appeared in a few rabbits.

The symptoms are not well marked at first. They consist of a slight nervousness then paralysis beginning usually in the hind legs. The paralysis gradually creeps forward so that, in from a few to twenty-four hours, the rabbit lies on its side unable to rise or move. It lives in this condition from a few hours to one or two days. In exceptional cases longer. Ordinarily the paralysis lasts from twelve to twenty-four hours.

Just prior to the development of the objective symptoms there is a rise of from one to two degrees in the temperature. This lasts from twenty-four to forty-eight hours when usually it rapidly subsides and, soon after the paralysis begins, it is subnormal, often reaching as low as 96° F., several hours before death.

The condition found on the post-mortem examination are also of much assistance in making a diagnosis. If the animal died from septicaemia or brain injury, there should be lesions recognizable in the brain or viscera. In the case of septicaemia a bacteriologic examination will reveal the presence of microorganisms. If death was caused by rabies the inoculation wound

*Bulletin No. 10, Bureau of Animal Industry, U. S. Department of Agriculture, 1893. Moore and Fish. Annual Report of the Bureau of Animal Industry, 1895-1896, p. 272.

in the head should be healed perfectly, there should be no abscess, and the meninges should be free from exudates and the brain itself should appear perfectly normal, except that in some cases there may be a slight injection of the blood vessels. The viscera are ordinarily normal in appearance, with possibly the exception of the liver, which is frequently found to be deeply reddened. The gastric mucosa occasionally shows dark patches which appear to be disintegrated hemorrhagic areas. A bacteriologic examination fails to reveal the presence of micro-organisms in either the parenchymatous organs or blood.

The differential diagnosis in experimental animals is not difficult. Rabbits inoculated with several varieties of pathogenic bacteria frequently exhibit symptoms of paralysis for a brief period preceding death. In cases of injury to the brain or spinal cord there may also be paralysis which in the absence of the history of the case might be taken for that of rabies. In these cases, however, the symptoms appear very soon after inoculation. This is especially true when the paralysis is due to mechanical injury of the brain or to irritating or septic substances, and in the case of the pathogenic bacteria if paralysis occurs, it is preceded by a period of greater or less time during which the animal was sick. The method of diagnosing rabies requires that the inoculated animals remain apparently well for a considerable length of time after the subdural inoculation and before the paralytic symptoms appear.

Although the diagnosis of rabies in the street dog is often exceedingly difficult from the symptoms manifested, it is a simple and very easily diagnosed disease if the rabbit inoculation method is followed. While we are as yet ignorant of the specific agent, we have in the brain such a localization of it that for all practical purposes the brain or spinal cord of the affected animal may be used, as a pure culture of the virus. With it the disease can be produced and with it, through a process of attenuation, the disease can be prevented as shown in the Pasteur treatment.

The economic importance of rabies is of much more significance than is generally supposed. During the past year numer-

ous outbreaks of rabies among cattle, horses and swine have been placed on record. The fact that rabid dogs frequently wander miles into the country and are prone to bite all men and animals happening in their way, frequently results in many victims from one dog. While statistics are not available from which even the approximate number of animals destroyed by this disease can be determined, it is known to be large. A conservative estimate would place the annual number among the thousands, and the human victims are numerous. While all who are bitten do not contract the disease, it is the exception, when a known rabid dog bites several animals that one or more of them do not die of the disease. The appended description of the cases and the method employed in making the diagnosis in animals dying in two outbreaks of rabies which occurred in this State during the summer and fall just past and which were brought to the notice of the Commissioner of Agriculture, and were investigated by his authority, are good illustrations of the disease.

Rabies near Saratoga.—According to reports, a shepherd dog belonging to Mr. Hart began to act strangely about May 12th. During the next few days he bit several dogs, three cows, Mr. Hart, his son and a neighbor. The neighbor took the Pasteur treatment for rabies. Two of the cows which were bitten and Mr. Hart died of rabies. There appears, however, to be a doubt concerning the diagnosis in the case of Mr. Hart. Unfortunately there seems to have been no post-mortem, and inoculations with a bit of the brain or spinal cord were not made. The son remained well. The bitten dogs were, with one exception, killed. These are the essential facts concerning the history of the cases as I gathered them from the letters received from Dr. Childs and Dr. Kelly. For the full particulars the reader is referred to the official report of Dr. W. H. Kelly, who made an investigation of the outbreak for the Commissioner of Agriculture.

Cow No. 1.—June 21st there was received at this laboratory, from Dr. Childs, of Saratoga Springs, the brain and a portion of the spinal cord, one kidney, a small piece of the lung and three mesenteric glands from a cow supposed to have died of rabies

and also to have been slightly affected with tuberculosis. In my absence the material was carefully looked after by Dr. P. A. Fish and Mr. R. C. Reed. The tissues were badly decomposed, but they decided to make inoculations from the spinal cord, which seemed to be in a better state of preservation. Accordingly, they inoculated two rabbits beneath the dura with a drop of a suspension of the spinal cord. One of these died during the night from septicaemia and the other remained well. The negative results in this case were of little value, owing to the advanced post-mortem changes which had taken place in the tissues before the inoculation.

This cow was thought by Dr. Childs to be affected with tuberculosis. Mr. Reed made a careful microscopic examination for tubercle bacilli, but failed to find them. A rabbit was also inoculated subcutaneously with a piece of the supposed tubercular nodule from the lung. It remained well.

Cow No. 2.—July 6th, I received the brain from a second animal which had died with symptoms similar to those manifested by cow No. 1. Mr. A. B. Kelly, who sent the brain, thought the animal had died of rabies, while others were quite as confident that the cause of death was something else. This time the brain was sent in glycerine and it was received in good condition.

July 7th, two rabbits, Nos. 43 and 44, were inoculated beneath the dura with a drop of the suspension of a bit of this brain in bouillon.

July 29th, rabbit No. 44 was found partially paralyzed at 7 A. M.

July 29th, rabbit No. 43 nervous but otherwise apparently well. At 10 A. M. No. 44 was completely paralyzed and No. 43 was apparently better, but towards night it became completely paralyzed. They died during the following day.

The rabbits were carefully examined and cultures were made from the various organs, but they remained sterile.

The lesions, or rather the absence of lesions, were typical of rabies, and there is no doubt that this was the cause of the cow's death. This positive diagnosis furnished the local health offi-

cers definite information which was necessary to enforce the proper management of the remaining animals which had been bitten. These were safely disposed of and no further cases have been reported from that vicinity.

Rabies at Chatham.—September 18th, I visited Chatham in company with Dr. Kelly to make an investigation into the nature of a disease resembling rabies, which had appeared there. From Dr. H. B. Ambler, who had charge of the cases, the following history was obtained.

About the middle of August a black, shaggy dog made its appearance in that village. It seemed to be quite friendly, but succeeded in biting several dogs, one horse and five cows before he disappeared from the community. No one seemed to know where this dog came from or where he went to. During the fore part of September two dogs died in Chatham of a disease resembling rabies. About the middle of September, a cow belonging to Mr. H., developed symptoms of rabies and died. A few days later a second one died and the brain was removed by Dr. Ambler. At the time of my visit a third cow was sick and a dog had just died. The dog was examined and its brain brought to the laboratory. The cow died three days later, but owing to Dr. Ambler's absence, was not post-mortemed. From the symptoms manifested on September 18th, there is little doubt of the accuracy of the diagnosis. Later, I received the brain from a cow in another herd which had been bitten by the same black dog. A cow in the adjoining field and the horse which were bitten by this dog died with symptoms of rabies. Later, another of the bitten dogs came down with the disease and was killed. Mr. H., the owner of the first cows mentioned, tore his hand on the broken horn of the first cow which died. Fearing that he had been inoculated, he took the Pasteur treatment.

INOCULATIONS FOR DIAGNOSIS.

Cow No. 2.—This was the second cow to die from the herd belonging to Mr. H. The brain had been kept in glycerine for two days. September 19th, rabbits Nos. 52 and 53 were inoculated

beneath the dura with a drop of the suspension prepared from this brain.

October 5th, rabbit No. 53 dies of paralytic rabies.

October 13th, rabbit No. 52 dies of paralytic rabies.

Dog No. 3.—This dog was carefully examined post-mortem September 18th. There were no lesions in the thoracic or abdominal organs. The brain was slightly congested. It was placed in a sterile jar and brought to the laboratory.

September 19th, rabbits Nos. 50 and 51 were inoculated with a suspension of the dog's brain. Rabbit No. 51 was inoculated subcutaneously; No. 50 beneath the dura.

October 8th, rabbit No. 50 was partially paralyzed. It died during the night. At this writing, November 24th, rabbit No. 51 exhibits the beginning symptoms of rabies.

Cow No. 5.—This cow was in another herd, but it died with symptoms of rabies. The brain was removed by Dr. Ambler and sent to this laboratory. It was received November 29th, late in the afternoon, and put on ice.

September 30th, rabbit No. 54 was inoculated beneath the dura.

October 16th, rabbit partially paralyzed.

October 17th, rabbit paralyzed. It dies during the night.

A second inoculation was made in one case, from rabbit No. 53.

October 9th, rabbit No. 56 was inoculated subdurally with a bit of the brain suspension from rabbit No. 53.

November 19th, rabbit No. 56 was paralyzed.

November 20th, rabbit found dead this morning.

Unfortunately, the brain of the horse was not secured. As it was bitten in the nose, and exhibited the symptoms of rabies, Dr. Ambler's diagnosis was undoubtedly correct.

The loss caused by this outbreak was about ten pet dogs, five of which were rabid, five cows and a horse. To this must be added the cost of the investigation and the expense of one Pasteur treatment. It is not known that this is all, for other animals in more distant herds may have been bitten unknown to their owners and their death attributed to other causes. Whether this

was true or not, the people of that community paid a good price for the privilege of allowing dogs to run the streets without muzzles.

Description of Plates.

I am indebted to Prof. S. H. Gage and to Mr. R. C. Reed for the photographs of the colonies of the anthrax bacilli.

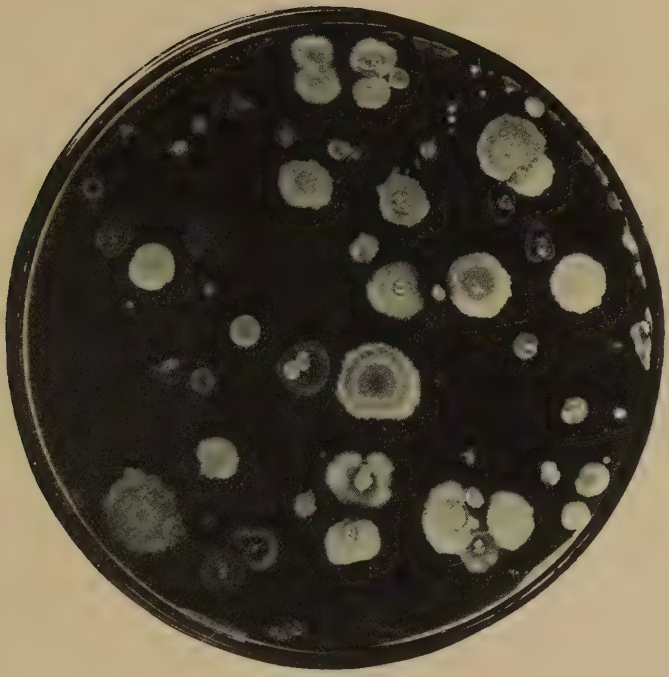
Plate VI. Anthrax colonies. 1. Photograph, natural size, of an agar plate culture of anthrax bacilli five days old. It shows the size and character of the surface colonies especially well. 2. This is a photograph of a small area of an agar plate under slight magnification; culture thirty-four hours old, containing many colonies, mostly within the medium. It shows the variety of forms taken on by the deep colonies.

Plate VII. Anthrax colony. 1. A photograph of a young thirty-four hour surface colony on an agar plate. Slightly magnified showing the filamentous ramifications of the growth. 2. A photograph, under a much higher power, of a portion of the edge of the same colony, showing the wavy course of the bundles of filaments and also the loops of filaments at the extreme margin of the colony.

Plate VIII. Anthrax bacilli. 1. Bacilli from a young bouillon culture. 2. Bacilli containing spores, also free spores drawn from a preparation made from a colony on an agar plate culture seven days old. 3. A drawing from a cover-glass preparation from the spleen of a cow which died of anthrax. It shows the bacilli with an apparent capsule surrounding them Bacilli magnified about 1,000 diameters.

PLATE VI.

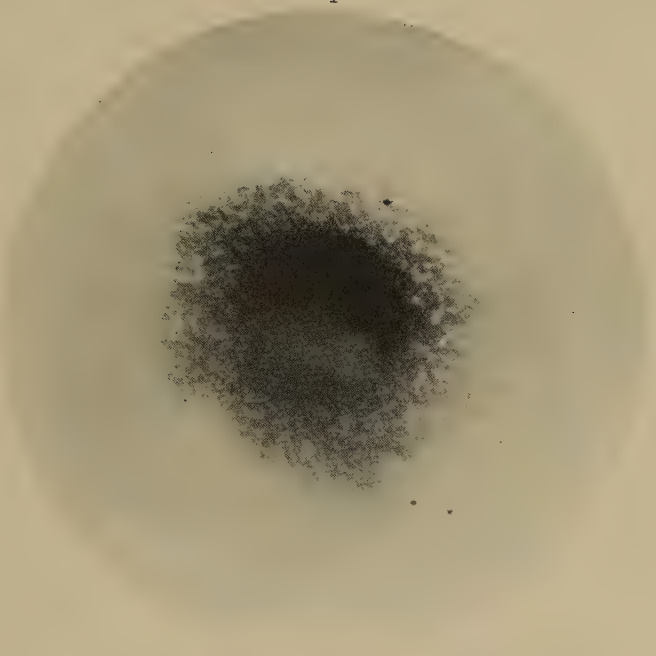
1



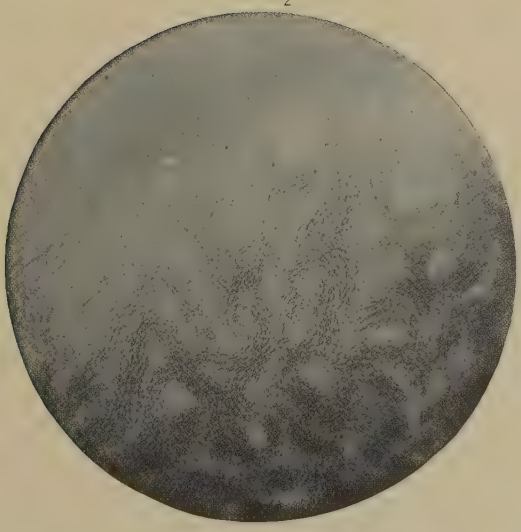
2

COLONIES OF ANTHRAX BACTERIA.

1



2

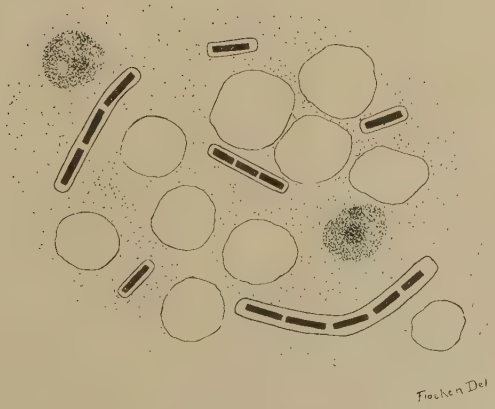


COLONY OF ANTHRAX BACTERIA.

1

2

3



ANTHRAX BACTERIA.

SIMON HENRY GAGE, B.S.,

Professor of Microscopy, Histology and Embryology.

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[Extract from Proceedings of 34th University Convocation, June 1896]

PHYSIOLOGY IN THE SCHOOLS

BY PROF. SIMON HENRY GAGE, CORNELL UNIVERSITY

That some knowledge of physiology and hygiene should form a part of the education of every human being will, I think, be granted by every one who believes that wisdom is safer than ignorance, that ignorance is not innocence, and that health and manly and womanly vigor are better than nerveless helplessness, and lastly that a knowledge of what the Creator pronounced very good is worthy the contemplation and thought of man. It is not necessary, however, to enter into an extended defense or advocacy of physiology and hygiene in the schools; they are there already by the sanction of the people and their representatives in the state legislature, and hence the real question upon which thought and discussion should be directed is: how can this study be made to yield the best results of which it is capable? The question is apparently easily answered by saying: put good text books in the pupils' hands, and supply capable teachers and ample time and facilities. While such an answer may seem sufficient, it is in the present state of educational progress only hollow sound. What is really needed is a discussion of what makes a good text book, how earnest men and women may become capable teachers, and how facilities, often inadequate, and time, mostly too limited, may be best utilized.

As to the text books — and there are many of them of various grades of excellence — none seem to me to come up to the standard which should be striven after. The defects are due either to an author's imperfect knowledge of modern physiology or to unfamiliarity with the actual needs of the school room. I believe no truly great text book for school, college or university can be created out of hand. It must be an evolution, a growth in its natural environment, the school room or laboratory where the pupils can help the teacher by their questions and difficulties. The atmosphere must be one of freedom for learner and teacher. Books written by so-called experts, under the *supervision* of the scientific department of a temperance organization, may, it is admitted, make the subject very exciting and entertaining. That is not what is here advocated, however, but a book by a teacher who, on the one hand, is truly an expert in the grade of schools where the book is to be used, and on the other, the pos-

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sessor of a knowledge of physiology at first hand; that is, he must have a knowledge that is recognized as expert by the physiologists of the world, then he must write under the *supervision* of his own conscience, not that of an organization.

It is a truism which can not be repeated too often or too emphatically that one can not teach what he himself does not know. Therefore, for the teacher of physiology the first requisite is knowledge—knowledge from books and of books and monographs, but greater than all book learning is knowledge at first hand from nature herself. Such knowledge has the precious quality of being alive, of being the leaven to vitalize the whole lump of knowledge obtained from books, and it makes teaching an inspiration to both teacher and pupil. Such information can only be acquired by the expenditure of considerable time and money. A six weeks course will hardly accomplish it although I hasten to add that a term at a university summer school or at a sea-side laboratory where the instruction is given by original investigators will give an uplift and inspiration to an earnest teacher that will be of inestimable value.

But, given the suitable text book and the capable teacher, *what* shall be taught and *how* shall it be taught? The question of instruction on the effects of alcohol and other narcotics need take but a sentence, for the subject has been most ably treated by Pres. Jordan and discussed by our superintendent of public instruction, Charles R. Skinner, and others. If I rightly understand them, my view corresponds with theirs and with those of my honored teacher, Prof. Burt G. Wilder, who is to discuss this paper. It is, in a word, to tell the truth, to present fairly both sides of the question, so that when the pupils use their own eyes and put the statements to the test of experience, as most of them surely will, they may feel, as well as know theoretically, that the statements made are true, and that the teacher's earnest counsel is reasonable and not merely lurid sentiment.

Another problem will confront the teacher, prepared as indicated above; that is the experimentation upon living animals for the purpose of instruction in the schools. If he has the knowledge requisite he will know that, except a few facts, all which is known of physiology and hygiene has been acquired by experimenting upon living animals or living human beings. If one stops for a moment to reflect, physiology deals with the functions or activities of living organisms, it has to do with the living, not with the dead. For example, how shall one know whether a plant is good for food, whether it is medical or poisonous? Of two white crystalline substances, like chlorid of sodium (common salt) and chlorid of mercury

(corrosive sublimate), how is one to know that one is almost indispensable for health and well being in both man and animals, while the other is deadly to both and also to plants? Certainly the desired information can not be gained by the chemist's test tube or by application to a dead animal. How are the splendid results of the modern physiological psychology being attained? Not by dissecting the dead, but by experimentation upon the living.

Shall our schools then become the chambers of horrors described by the anti-vivisectionists? Heaven forbid! The fundamental facts of physiology, those most intelligible and useful for the pupils in the schools, can be demonstrated for them and by them without the infliction of pain or even discomfort; and most of them can best be performed by the pupil upon himself. Let us take a few examples: every child knows that there is feeling, as he calls it, in the skin; he also knows the sensation of cold. But he, and indeed most grown people, do not know that the tactile sense does not reside in every part of the skin, and so of the temperature sense. If some object like the rounded end of a lead pencil or a bit of steel be drawn carefully over the skin, say upon the back of the hand, it will be felt simply as an object over the tactile areas, while over the temperature areas there will be a sensation of cold. Then how easy it is to give the real physiology of muscle by having each pupil perform some definite movements of the arms. If the muscles are felt during these movements, especially if some force is exerted, as in lifting a weight, the changes in the form and consistency of the muscles can be easily determined. It will also probably be a revelation to the pupil to find that in raising the arm, for example, the muscles around the shoulder and at the elbow, which by themselves would tend to lower the arm or draw it outward or inward, also contract. After such an experiment it will not be difficult for the pupil to understand that, for the steady and definite movements of parts where the joints give considerable freedom, it is necessary that there should also be a moderate contraction of antagonistic or opposing muscles which by themselves would cause movements in other directions; that is he will gain, by such a simple experiment, the ground idea of coordination.

Perhaps none of the experiments that can be performed are of more practical utility than some simple ones in digestion. It is now very easy to obtain from the pharmacies the ferment of the stomach or of the pancreas. With these ferments and a glass vessel the pupils can see for themselves the solvent action on various forms of food. They can see that finely divided food is more quickly dissolved than large masses, and

hence one of the principal advantages of thorough mastication. So if the ferment of the saliva or pancreas were mixed with raw starch and with cooked starch it could be seen, with a distinctness never to be forgotten, that fire is a powerful ally of the human digestive organs. These experiments are also instructive because the processes are practically identical with those going on in the living body, and thus illustrate the side of physiology that may be demonstrated without experimenting on a living organism.

The circulation of the blood is a fact of such fundamental importance and so interesting in itself that every student ought to have the privilege of viewing it under a microscope. This can be very easily shown in the web of a frog's foot or in the external gills of a water salamander like the Necturus. If a little ether is put in the water containing the animal it will soon become anesthetized without interfering with the circulation. The ether will render the perfectly painless observation successful without even arousing the apprehensions of the animal, which soon revives when placed again in fresh water, and appears as happy as if nothing had occurred. The experiment will also illustrate in a striking manner the effect of anesthetics on all living beings. A very far-reaching lesson may be given by having each pupil perform some of the simpler experiments showing the illusions of the senses. These are so graphic that the dullest can not fail to appreciate the fact that the only safe way is to look on all sides, to verify appearances by applying as many tests as possible; in short, to appreciate the *scientific method* which is so tersely expressed in the words of Scripture, "Prove all things; hold fast that which is good."

So far nothing has been said about anatomy. What place shall it have in a course on physiology? Undoubtedly it is a very great help in the study of function to have a good knowledge of the structures performing the various functions; but it seems to me that in many books, and in some courses in physiology, anatomy is so preponderant that the physiology is too much lost sight of — that is, the mechanism is exalted above its achievements. Only the grossest functions of the organs, like the supportive action of the bones, can be deduced from the anatomy alone; yet it is certainly the fact that, after the physiology has been once determined by experiments upon living beings, one can often see how admirably the structure of an organ is correlated with the performance of its function. For example, the small intestine with its millions of villi projecting like so many rootlets into the digested food seems from its very structure destined for absorption.

On the other hand, if one studied never so profoundly the structure of the salivary glands and the pancreas he would never know that they produce digestive liquids without experiment, and much less would he know that the one is so limited in its power (saliva) and the other so unlimited and powerful as a digester. So I think the microscopic structure or histology is liable to be made too much of in elementary books and teaching. But, for a few points, the microscope is truly a revealer; e. g. the mystery of the current by which the air passages are swept clean of dust and other particles is simplified by miscroscopic observation which shows the tireless multitude of cilia with their ceaseless waving. The fact is not to be forgotten, however, that even in this case only the minute agents and their method of work have been found. *Why* they work is as great a mystery as ever. So also in the study of the circulation of the blood under the microscope one can see how closely every living element is surrounded by the blood capillaries, and how ceaselessly the blood corpuscles and the plasma move along, to be followed by a never ending fresh supply.

The purpose of this paper has not been unduly to criticize, but to throw out what I hope will prove to be a few helpful suggestions. That the efforts of the teachers of this state are earnest and devoted is thoroughly believed. That the pupils they instruct are not all acquainted with sufficient anatomy and the fundamental principles of physiology is also known by the examinations for entrance to the university in which I have the honor to teach. From carefully compiled statistics obtained during the last few years it is found, however, that the pupils who have studied physiology something in the way indicated above have been far more successful than those who have merely studied the books.[a]

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[a] Facts concerning entrance examinations in physiology at Cornell university: the great majority of students enter in physiology with the other studies, from regents diplomas or from graduation at accredited schools.

From the reports of the president and dean it was seen that about one in 16 so entering could not remain in the university on account of defective scholarship, while of those taking entrance examinations at the university one in eight was dropped, showing that the more poorly prepared were those who came for examinations including physiology. Physiology papers of 195 of the latter class have been looked over with reference to determining the quality and kind of preparation made, as taken from answers to questions.

The average standing of the 195 was	53%
The average standing of those having dissection and drawing	59%
The average standing of those having nothing but books	47%
The average standing of those self-prepared	59%
The average standing of those having previous college training	66%

If in closing I may briefly epitomize, it seems to me, that the best results may be obtained in physiologic instruction in the schools as follows:

1 Text books written by able teachers who know the subject at first hand should be provided.

2 The fact should be emphasized that physiology is very real, and that every one may demonstrate upon himself many of the most striking and fundamental phenomena; e. g. how quickly will the pupil see that it is not necessary to go to the teacher or to the book to find out the number of heartbeats and respirations per minute, and that both are greatly accelerated by exercise or excitement.

3 Anatomy should not overshadow physiology, but nice structural adaptations whereby specific functions are performed may be pointed out and worked upon with great advantage; e. g. the valves in the heart, the veins and lymphatics, the forms of the joints, etc. Such knowledge is interesting and would aid all. Perhaps also it might arouse some slumbering genius whose future efforts would reveal adaptations now hidden.

4 The teacher should inspire his pupils with respect for the human body and its powers, and with due sympathy for all living things. Lastly he should impress upon them with solemn earnestness the fact that their physical and moral health is largely in their own hands, and that the physical and moral laws of their being are inexorable.

ZOÖLOGY AS A FACTOR IN MENTAL CULTURE.

BY PROFESSOR SIMON H. GAGE, CORNELL UNIVERSITY, NEW YORK.

It is not my purpose at the beginning of this address to weary you with apologies. I wish simply to pay my tribute of respect and admiration to the great zoölogist and still greater man, David Starr Jordan, whom I, with you, hoped to hear this day.

It is with regret that we miss his noble presence and speech, but there is also an element of gratification, for he is the fittest possible representative the government could have chosen as head of the commission to investigate the seals in Alaskan waters, and thus to furnish the definite information upon the basis of which the two foremost nations of the globe can honorably unite in a common cause.

In the able addresses which have preceded there has been shown with great clearness and force how the mind of man, cultivated by the disciplines of physics, chemistry and botany, has been made fitter to yield the flower and fruitage of noble effort. What then has zoölogy contributed, and what is it likely to contribute when used as one of the agents or means in the cultivation of the mind! And as with the agriculturist, every factor is of interest which can serve in adding to the productiveness of the soil and the quality of what is produced, so to us, mind or soul culturalists, every factor in mind culture is of vital interest. What then is this zoölogy which is spoken of as a factor in mental culture? As botany in its broad sense includes everything known and knowable concerning plants, so zoölogy includes everything known and knowable concerning animals; or as botany is plant-biology, so zoölogy is animal-biology, and deals with the form, structure, activities, development and classification of animals and their economics or relations to each other and to man. And if we include *Homo sapiens* among the animals, it will be seen that if man and his doings are a part of zoölogy, zoölogy, like every other center of knowledge and investigation, reaches out to infinity in every direction like the rays from a luminous point.

Although most of us are engaged in the profession whose high aim is to aid in starting the young on the road that leads to a truly liberal culture, it may perhaps be best, before discussing the part which zoölogy has taken and may take in liberal culture, to understand dis-

tinctly what is meant by culture or education, and especially by liberal culture. It seems to me that no one has so well pictured the ideal liberal culture or education, or has realized it more surely in a noble life than the great zoölogist, Huxley. Hear his definition: "That man, I think, has a liberal education, who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of nature, and of the laws of her operations; one who, not a stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; one who has learned to love all beauty, whether of nature or of art, to hate all vileness and to respect others as himself."

What has zoölogy done to make such culture possible? First and foremost, it has aided most powerfully to render free the human mind; and without freedom no human soul can enter into the fullness of its kingdom; the true glory of this kingdom is not for slaves.

At the present day no Cæsar on the banks of a Rubicon would make his crossing depend upon the omens gained from the flight of birds. We do not decide upon attending the meetings of the National Educational Association by the key in which the wolf howls or the quaver of the owl's hoot. We no longer expect our acquaintances to imitate the transformations of the companions of Ulysses in the palace of Circe, no matter how appropriate such transformations might be. No longer do we expect to see birds and beasts produced in the fruits of trees or from decayed wood washed up by the sea; nor do we think that bees and other insects are generated by decomposing flesh. We know that no living thing exists without having received its life from a living parent like itself. Our path is no longer beset with hippogriff, basilisk or dragon, and our high hopes and noble aspirations are no longer at the mercy of fairies and genii. Living beings, as well as lifeless matter, are subject to law. "Thus far and no farther," applies to them as to the waves of the sea or the rush of a comet. The fairies are fled, the genii banished, the mermaid and the remora are captured, classified and harmlessly repose as objects of curiosity or instruction in the great museums. Zoölogical truth has freed us from their slavery.

Now that freedom has come, how shall this subject be made an efficient means of mental culture, and what will its fruit be? In the first place, as for the subjects, the discussion of which has preceded this, Nature herself must be interrogated. The successful student of

zoölogy, to quote again the trenchant words of Huxley, "absolutely refuses to acknowledge authority as such. For him, skepticism is the highest of duties, blind faith the one unpardonable sin. And it cannot be otherwise, for every great advance in natural knowledge has involved the absolute rejection of authority, the cherishing of the keenest skepticism, the annihilation of the spirit of blind faith; and the most ardent votary of science holds his firmest convictions, not because the men he most venerates hold them; not because their verity is testified by portents and wonders, but because his experience teaches him that whenever he chooses to bring these convictions into contact with their primary source, nature, whenever he thinks fit to test them by appealing to experiment and to observation, nature will confirm them. The man of science has learned to believe in justification, not by faith, but by verification." To complete this first law in the Decalogue of the scientific student, it should be followed by this from his address upon Descartes' Discourse: "When I say that Descartes consecrated doubt, you must remember that it was that sort of doubt which Goethe has called 'the active skepticism, whose whole aim is to conquer itself;' and not that other sort which is born of flippancy and ignorance. But it is impossible to define what is meant by scientific doubt better than in Descartes' own words. He says: 'For all that, I did not imitate the skeptics, who doubt only for doubting's sake, and pretend to be always undecided; on the contrary, my whole intention was to arrive at certainty, and to dig away the drift and the sand until I reached the rock or the clay beneath.'"

In this spirit, then, of reverent skepticism, of scientific doubt, must the teacher of zoölogy teach and the student learn. And if this is the spirit, the teachers are but elder brothers a little farther advanced, knowing a few more of the delusions and pitfalls which beset the way. Teacher and pupil work together — the one inspired by the great works of all his predecessors and by nature herself, and he in turn inspiring and helping the student in his efforts. Such teachers, such pupils and such inspiring surroundings are described by Agassiz in his notable address upon Humboldt: "I was a student at Munich. That university had opened under the most brilliant auspices. Almost every name on the list of professors was also prominent in some department of science or literature. They were not men who taught from text-books or even read lectures made up of extracts from original works. They were themselves original investigators, daily contributing to the sum of human knowledge . . . and they were not only our teachers but our friends. . . . We were often the companions of their walks, often present at their discussions, and when we met for conversation or to give lectures among ourselves, as we constantly did, our professors were often among our listeners, cheering and stimulating us in all our efforts after independent research.

My room was our meeting place — bedroom, study, museum, library, lecture-room, fencing-room — all in one. Students and professors used to call it the little academy. . . . It was in our little academy that Döllinger, the great master in physiology and embryology, showed to us, his students, before he had even given them to the scientific world, his wonderful preparations exhibiting the vessels of the villosities of the alimentary canal; and here he taught us the use of the microscope in embryological investigation."

A rare privilege is it, my fellow-teachers, to be not only teachers, but friends to our students. For Agassiz, Humboldt and Cuvier were his teachers and friends; for Darwin, were Henslow and Sedgwick. Darwin paid his debt of gratitude by never turning a deaf ear to an inquirer; and in the "Origin of Species," the "Descent of Man," and his other works, he becomes a companion to all of us and takes us into his confidence. And Agassiz, what shall we in America not say in gratitude to him! Who like him breathed confidence into the ardent young men who are now bearing the burden and heat of the day in the noble onward march of American science? Who like Agassiz showed us our rich inheritance and inspired this New World to arise and take possession of its own? As in holiness, so in literature, so in science, it is the living gospel, the living teacher whose inspiring touch awakens a spirit that thenceforward can never repose in idleness and indifference, but with a noble enthusiasm ever presses onward.

But, after all, the student comes back in his own mind to the serious personal question: How shall I begin; what can I do to gain this mental culture? Though the practice is difficult, the theory is simple. Observe, study, reflect. But reflection must always follow the others or there will result only empty subtleties, while without reflection, observation and study are barren and fruitless. Perhaps it is unnecessary to add that zoölogical culture does not come from the study of a fourteen weeks' course, prepared by a man who does not know the subject at first hand. Learning the names and a little of the structure and some of the habits of a few animals is not zoölogical culture, although it may be a beginning. It is such a beginning as learning the Greek alphabet is for the appreciation of the immortal epic of Homer and the whole glorious array of Greek art and literature. Or it is such a beginning as a knowledge of the multiplication table is for mathematics. I have thought sometimes that in our enthusiasm for scientific study we have cut and trimmed and selected for our fourteen weeks' courses till verily when our students ask us for bread we have only a stone to offer.

Did Darwin think out natural selection and the survival of the fittest, or Agassiz the glacial theory in fourteen weeks? Not every pupil can spend twenty-eight years or even a tenth of that upon a single subject; it nevertheless remains true that the mental culture gained by the

study of zoölogy will, as with other disciplines, depend first upon the original power of the student,* and second upon the time and energy devoted to the subject.

If we take some of the aspects under which zoölogy may be considered, as anatomy, physiology, embryology, classification and economics, and think for a moment what is involved in understanding them, perhaps it will be clear why it is so insisted upon that to gain true mental culture from zoölogy time is required. Time for observation and study, and, after that, time for reflection, so that there may be assimilation and some kind of real comprehension of the subjects considered. And I take it that in the comprehension gained lies the very pith and marrow of whatever culture zoölogy can give.†

If anatomy is considered, what a field is there for observation and study. This animal machine with its muscles and nerves, digestive system and brains, bones and sinews; what nice adaptations they show for their various purposes, and to the far seeing eye how many bungles and compromises there are too. As compared with the machines made by human hands the animal machine is as a printed volume to a simple diagram. In these archives are stored the history of the past, the ascent or the descent from something different, but like the manuscript that has been written over and over after partial erasure, so is this structure clear only in part. Some words have been spelled out, but the master to decipher the whole manuscript is yet to appear.

And physiology, that is, the activities of the living animal, how beautiful they are, how diverse. The mother love that saves the world, the mighty thought of Newton or Shakespeare are somehow

*The original ability of the student is mentioned prominently in this paper because in too many discussions upon subjects for culture, teachers and methods, it seems to be assumed that, given a proper subject of study a good method and an expert teacher, the desired result will be attained. That is, the material upon which the teacher works is tacitly left out of the count, and the teacher is blamed or the method or subject is condemned if cultured men and women are not turned out regardless of their ability. It is a historical fact, however, that with good or poor teachers or with no teachers, with good or poor methods or apparently with no methods, and with a great variety of subjects, cultured men and women have appeared in all ages. Subject, method and teacher are only helps that the student uses according to his ability, and important as the helps are, the result depends infinitely more upon the native ability of the student than upon the helps. Subject, method and teacher cannot create they can only modify or facilitate development.

†It is not for a moment claimed that so thorough a study of zoölogy as is here advocated is the only way to obtain *useful* information concerning the animals upon the earth and in the water. To continue the comparison used in the text, a little knowledge of Greek is useful in studying astronomy and for gaining a better appreciation of English words derived from the Greek, but no one claims that such elementary knowledge is Greek culture. So information concerning edible fishes, mollusks and the ordinary four-footed creatures, a knowledge of poisonous snakes, useful and harmful insects, and many other practical and useful things, may be known about the animals, but that is not the knowledge that makes culture. although the profounder knowledge advocated in this paper and which comes with culture in zoölogical science includes this which in itself is merely practical and useful. Real science or culture gives foundation principles which alone make applied or useful knowledge possible in the higher fields. While I believe most thoroughly that zoölogy for culture is a very serious subject and one requiring much time as well as much observation and reflection, it is not desired for a moment to discourage the study of zoölogy, or indeed any subject, for purely utilitarian or practical purposes. While indeed such knowledge cannot be called culture, it is often true, as aptly stated by Prof. Atkinson in discussing this series of papers, that study for purely utilitarian purposes is very likely to lead to the higher kind of study which does make for culture.

bound up with or in this living matter whose chemistry and physics even, still almost wholly elude us.

Then if we turn to embryology and try to trace with patient care the work of the unseen artificer who arranges the apparently simple and almost structureless mass of the ovum into heart and brain, muscle and nerve, and changes the formless into forms of beauty and power, be it butterfly, bird or man, we cannot but receive culture and uplifting; for are we not seeing with our own eyes what is described in the sublime words of the Psalmist: "I am fearfully and wonderfully made . . . My substance was not hid from thee when I was made in secret and curiously wrought in the lowest parts of the earth. Thine eyes did see my substance, yet being unperfect: and in thy book all my members are written, which in continuance were fashioned when as yet there was none of them."

Classification requires knowledge of all the above, for it is an arrangement in due order of the complex beings of the earth from the microscopic animalcule to the mighty elephant. For the classification to be successful the mind must see the true relations between all the forms, must know their structure and activities and how they were curiously wrought and transformed from generation to generation for unnumbered ages; in a word, the classifier must know their evolution; or, in the noble words of Agassiz, he must 'become the translator of the thoughts of God.'

And lastly we come to the economics of zoölogy, that is, the relations of the animals to the earth, the plants, to one another and to man, and his relations to them. Here one is brought face to face, not merely with the glory of living, thinking and acting, but with destiny; with the solemn fact of life *with* death, or, more truly stated, life *by* death. More are born than can possibly survive even the short span granted for the typical life cycle. Indeed, it almost appears as if nature in her efforts for life had become a Moloch of death. How graphically Darwin has painted the picture of this scene of strife, the plant crowding its neighbors to get a little more sunshine or nutriment, the animals crowding each other and devouring both the plants and their fellows; and then there is the whole foul brood of animal parasites. In these latter days we know also that the plants are not simply content to strive for sunshine and soil in order to elaborate from the inorganic world the compounds that alone make animal life possible, but in turn, a multitude of them, which no man can number the bacteria, are devouring the animals, including man. The knowledge of this fact, so largely due to the great Pasteur, has given new significance to hygiene and a new meaning to cleanliness.

This death and disease of the animals by means of the pathogenic germs, which also bring disease and death to man, has put a new aspect upon man's relations with the animals. They are indeed his

kin, and *zoölogical economics* may almost be said to have become dignified into *zoölogical ethics*. None stands or falls alone. The earth is the mother of us all, but she bestows her gifts in a very roundabout fashion sometimes. The soil, air and sunshine of Montana may furnish the conditions for the grass; the old world gave the foundations of the life which we uow find realized in perfect form in the sturdy beeves which grow and fatten on the Montana grass; and finally, without a thought of the sun, or the soil of Montana, or of the life which they made possible, or of the fear and suffering which may have resulted, we calmly nourish ourselves on the beefsteak while discussing politics, education or the hereafter. But often enough to take away undue indifference, the beef or other food may contain the germs of what is death to us, although it may be teeming life to the germs; and there is forced upon us a consideration of our relation with our living environment. If knowledge and reflection are sufficient, it does not take a very great philosopher to see that the economical standpoint changes with the change of organism. For the plant, the sunshine, the soil and the rain are for it. For the plant-eating animal, sunshine, soil and rain are to produce the plant for it. And from man's standpoint, all are for him; but if we change the standpoint slightly and judge of the workings of a tiger's mind by its actions, we would see that sunshine, soil, rain and dew, the plants, the fat beeves and even man himself are for the tiger's sole benefit.

Surely if the other sides of zoölogy call for imagination, acute observation, profound study and cold, logical reasoning for their comprehension, this side demands all these and, in addition, a philosophic spirit, that flower of the cultivated human mind.

I think what has been said will suffice to show that in zoölogy there is a factor of true mental culture; and that by it the philosopher, the philanthropist, the man of affairs, is better fitted in his own sphere for work and for leisure. If the student feels that some of the inspiration to this culture has departed, that the structure, function, embryology, classification and economics of animals have been almost all discovered and determined, and may be found in the ponderous volumes and monographs in the great libraries, refer him to Aristotle, Darwin, Dana, Gray or Agassiz, or to any of the devoted men and women who have been and are trying to find out the truth and to follow it. They will say: Be of good cheer and not faint-hearted. Look and listen with brain as well as with eye and ear, for on every side are thrilling sounds whose music no human ear hath heard, and sights whose exquisite beauty no human eye hath seen.

In closing this address I cannot summarize my belief in the cultivating power of the earnest study of zoölogy better than by saying that a profound contemplation of the factors in the problem of animal life on the earth will bring out and cultivate the mind. It will show man

his true relations to his fellow men and to his lowly fellows, the animals. It will not fill the mind with pride, for ultimate knowledge is as yet unattainable; it will rather give the humility expressed by Job: "Canst thou by searching find out God? canst thou find out the Almighty unto perfection?" or by Newton: "I do not know what I may appear to the world; but to myself I seem to have been only a boy playing on the seashore and diverting myself in finding now and then a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." And another from one of the foremost physicists of our own day, Sir William Thompson, at the jubilee of his appointment as professor of natural philosophy at the University of Glasgow: "One word characterizes the most strenuous efforts for the advancement of science that I have made perseveringly through fifty-five years; that word is failure; I know no more of electric and magnetic force, or of the relations between ether, electricity and ponderable matter, or of chemical affinity, than I knew and tried to teach my students of natural philosophy fifty years ago in my first session as professor." Yet there is also the pæan, if not of victory, of the consciousness of power that comes to him whose mind has been truly cultured by the disciplines brought before you is this series of addresses and none has a surer right to that consciousness or with a surer voice has expressed it than the zoölogist in whose place I stand to-day: "The world of thought and the world of action are one in essence. In both truth is strength, and folly and selfishness are weakness. Say what we may about the limitations of the life of man, they are largely self limitations. Hemmed in is human life by the force of the fates; but the will of man is one of the fates, and can take its place by the side of the rest of them."

HISTOLOGY AND METHODS OF INSTRUCTION.*

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In the preface to the first edition of his *Handbook of Human Histology*, Kölliker made this significant remark: "Medicine has reached a point at which microscopical anatomy seems as necessary for a foundation to it as does the gross anatomy of the organs and system; and when a profound study of physiology and pathology is impossible without an exact knowledge of the finest structural details." If this was in the main correct in 1852, when Kölliker first wrote it, how much more is it so at the present day when not only medicine, but the great science of biology is taking such a prominent position in the minds of men. Indeed, in its broad aspect medicine is but one of the details of biology, and pathology is biological activity perverted by abnormal influences and environment; and since the time when Virchow's cellular pathology appeared, it has been known that the real seat of this perverted activity resides in the microscopic elements or cells which compose the different organs and tissues. Likewise is it known with the greatest certainty that all normal activity goes on in the microscopic elements making up the tissues; and finally the germs of a new generation, the bearers of heredity by which the past reappears in the future, are likewise, in most cases, microscopic elements. In a word, without the microscope, knowledge would be turned back a century and the certainty concerning many things in biology today would give place to the baseless speculations of the dark ages.

All teachers of histology have, of course, the same general object in view, viz.: to give their pupils a knowledge of the

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microscopic structure of the body. Naturally, and of necessity the way in which different teachers go to work to give their pupils this knowledge will depend on the teacher's view as to the special end to be attained by the study, and secondly on the facilities he has at his disposal. The views expressed in this paper may not accord with those of teachers, in whom experience and special surroundings have given rise to fixed convictions, but it is hoped that some of the younger teachers may get suggestions from it that will aid them in making the most of their surroundings and facilities ; it is hoped also that the subject of histology will be seen by them to be vitally important for an understanding of physiology, morphology and pathology. It is hoped also that the end of histology will not seem to any to be reached when an organ or tissue has been fixed, hardened, cut with an expensive microtome, stained in brilliant colors and finally embalmed in Canada balsam. It is hoped rather that all of this labor and pains may be seen to be only to help one see the physiologic, morphologic or pathologic processes and relations exhibited by the tissue more clearly. If the microscopic preparations have no such meaning to the student then they are no better than so many Chinese puzzles.

It seems to the writer that the first step in histology is a thorough study of the chief instrument used, the microscope. The microscope is to aid the eye in seeing what is invisible or not satisfactorily visible without it, and unless one knows something of the methods of making this helper to vision a real helper, much time will be wasted. This is especially true of the better forms of instruments. One can use with some satisfaction a simple magnifier without instruction or much study, but a good modern, compound microscope to be of much use must be well understood ; one must know its possibilities and limitations. It seems to the writer that time is really saved for histology by devoting a few weeks to the microscope itself, and to the methods of micrometry, drawing, the use of the micro-polariscope, the micro-spectroscope and other accessories. Otherwise one must learn

these things when he is trying to make use of them in solving some problem in actual work.

It may naturally be asked what kind of a microscope is necessary for the pursuit of modern histology? While a great deal of excellent work may be done with comparatively inexpensive apparatus, costing from $25 to $50 and magnifying from 25 to 500 diameters, one cannot follow out the finer details in histology and pathology with such an outfit, and in some parts of pathology, where bacteria are involved, one would be practically helpless. Some such outfit as the following seems necessary: Dry objectives of 50 mm. (2 in.), 16 mm. ($\frac{2}{3}$ or $\frac{3}{4}$ in.), and 3 mm. ($\frac{1}{8}$ in.), and a homogeneous immersion of 2 mm. or $1\frac{1}{2}$ mm. (1-12 or 1-16 in.) There must be some form of substage condenser. This, like the objectives, will serve one in proportion to its excellence. The stand of the microscope should have a coarse and fine adjustment for focusing, the pillar should be flexible, so that it may be used in either the vertical or inclined positions, and the substage should have a rack and pinion adjustment for the substage condenser, and an arrangement for centering. Fortunately such an outfit can be had at the present day for less than $100, if supplied with ordinary achromatic objectives; but the cost is much greater if the best achromatic or apochromatic objectives are obtained. It is of the greatest advantage also to have a mechanical stage of some sort. The removable mechanical stages after the Tolles-Mayall pattern are inexpensive and most satisfactory.

For laboratory work there are two methods, the one allowing students to come at their convenience and accomplish as much work as they can or wish to. The other plan is to give a medium amount of work, which must be accomplished in a given time. The students are required also to come in regular sections. The last way seems to the writer the best. Experience has shown that regular sections, in which the teacher devotes his whole time to the laboratory, yield better results. There is a kind of momentum gained in this way that overcomes the inertia of the less energetic,

and for those that get through with the small amount of work that must be assigned for a lesson there is abundant opportunity to consult monographs and go more deeply into the subject than is required of the average student. To conduct a class in this way, however, necessitates abundant, well-lighted space, plenty of tables and microscopes, and other laboratory facilities. It can be readily seen that laboratory work in histology carried on in this way requires an expensive plant. If the subject is to be taught at all, this is the only economical way, however. To keep a laboratory open all day and every day, the teacher being on duty all the time, is wasteful and the results unsatisfactory ; as unsatisfactory and uneconomical as it would be to divide a Greek class of twenty up into five to ten sections for recitation. The last section would hardly gain much inspiration from the teacher, and such a teacher would not be likely to add much to comparative philology or anything else.

In the actual instruction it is believed that there should be a combination of lectures and laboratory work. The lectures serve to give the students broad and general ideas and the relations of the subjects to each other ; that is, they give the fundamental facts, principles and relations, which are the result of the investigations of the best workers. The best books and monographs are referred to and shown, and put at the students' disposal. This is done because it is believed that every one should take advantage of the gain made by his predecessors and not try to start at the beginning. Life is too short for that, and progress would almost or quite cease if the gain made by our predecessors could not be made use of. From a long observation it is believed that the student who has the power to make independent investigations should have these helps, so that he may recognise the attainments of others and start from their vantage ground to explore new fields. For the student who has not the power for original investigation this is the only way to help him. He cannot go where there is no path.

In the second place there should be abundant opportunity

for laboratory work where the student is brought into direct contact with the truths of nature in nature herself, and if he is an honest man he must work very hard to make out these truths, no matter how much help he has been given by lectures and books.

In the laboratory work each student should learn and practice all the principal methods. A preparation made by the student himself from getting the tissue until it is mounted and labeled means something to him ; it is connected in a very definite way with the organ or part in the animal. He also gains skill in manipulation, and without skill in manipulation no real progress can be made in any science. Exact notes, with dates and drawings, are necessary to avoid vagueness and to prevent the student from deceiving himself in the belief that he has gained certain knowledge when he has not. These notes and drawings, and the students' specimens, duly labeled and catalogued, should be most conscientiously scrutinised by the teacher. They give him an opportunity that nothing else can to help the student by correcting erroneous conclusions and by aiding him in gaining skill in manipulation. It may well be asked, however, if it is possible to get a class through the tissues and organs of the animal body by having each student perform all the operations for himself. It is admitted that the time necessary would be too long, and for most of the students much time would be unnecessarily used in mere mechanical operations. The plan advocated is to have each student learn all the fundamental processes in modern histology, and learn them by repeated operations, but the loss of time by mere repetition after the processes have been mastered may be avoided without injury by furnishing most of the preparations either already cut or imbedded ready for cutting. It is believed that every preparation, with rare exceptions, should be in part at least, the work of the student. If then for these partly prepared preparations full data are given concerning the methods used the student will have no trouble in making the proper connection mentioned above when he performed

all the work himself. It is believed that the ground can be covered in this way and it is known from experience and observation that the intellectual independence gained by the personal work of each student will repay all trouble on the part of the teacher—for it is more trouble to guide the student than for the teacher to do the work himself. The student will gain also the power to use the work of others, and to judge it at its true value as he could in no other way.

In the actual work carried on by the writer, lectures are given to the entire class, and, then, for the laboratory work sections of about fifteen are taken for not less than two hours at a time. If a period of less time were given, so much of it would be used in getting ready to work and in clearing up that not enough actual, productive work could be done to repay the effort. Each student is given the use of a locker ; each one prepares nearly all of the reagents used by him, and each one learns the methods of isolation, of sectioning by the collodion and by the paraffin method, both with simple and inexpensive and by the best modern apparatus ; and all have opportunity to see the method of making frozen sections, so largely used in diagnosis in pathological work. There is a large cabinet of specimens illustrating microscopy, histology and embryology, made and labeled and catalogued with all possible care, to serve as models for the students and for reference. The cabinet has been found very valuable for stimulating independent work. If one sees only figures of microscopic objects he may feel that to make actual specimens which shall show the objects with equal clearness would be impossible for a student, but if such specimens are at his disposal he is stimulated and encouraged to prepare similar ones for himself. He soon learns also, in studying actual specimens, that many of the figures in the books are composites,—made by combining the best features of several preparations.

For convenience, the animal body is divided into the following groups of tissues and organs. The arrangement is

more or less logical also on embryologic, physiologic and morphologic grounds :

1. Epithelia, including endothelia.
2. Connective and supporting tissue (Areolar tissue, tendon, ligament, bone, cartilage, etc.).
3. The muscular system.
4. Blood and lymph, *i. e.*, the fluids of the body and their corpuscles.
5. The blood and lymph vascular system.
6. The digestive system.
7. The respiratory system.
8. The genito-urinary system.
9. The skin and its appendages.
10. The nervous system and the organs of sense.

In teaching, the following guiding principles have been followed :

1. It has always seemed to the writer that one of the most important steps in the knowledge of the structure of the tissues and organs is a thorough knowledge of the gross anatomy. The histologist must, first of all, be a thorough naked-eye anatomist. He must also be a physiologist, and he will naturally become an embryologist, for without the knowledge that embryology gives, the adult structure is frequently unintelligible, and without physiology, structures are, in many cases, meaningless. The wise histologist is then a physiologist, an embryologist and an anatomist. From the naked-eye appearances he passes as necessity requires, from the contemplation of organs and tissues, first to a low power and then for the finer and finest structural details to the highest powers available. But he never loses sight of the fact that the details alone are far less intelligible than when they are correlated with the organ or tissue to which they belong.

2. It seems so natural and logical in teaching the fundamental facts concerning the morphology and structure of the body to refer to the mode of development, that for several

years the students have not only been taught in lectures from the embryological standpoint, but each student in the beginning has put into his hands, in the laboratory, preparations of the ovarian ovum to represent not only a typical cell, but the fundamental fact that the complex body of the largest animal is derived from the ovum. Then preparations of the blastula with a single layer, representing in a general way a simple epithelium, are studied, and then the blastula with a wall several cells thick, representing in general a stratified epithelium. Other preparations are studied, showing clearly the mode of formation of the axon or notochord from the entoderm, and of the neuron or central nervous axis from the ectoderm. After studying these preparations it means something to the student when he reads or hears in lectures that a given tissue or organ is derived from one or the other of the germ layers.*

3. Each tissue is studied fresh, so that correct notions may be gained of the natural appearance of the organs and tissues and their structural elements unaffected by reagents.

4. Every organ and tissue is studied alive, so far as possible, in order that the function and the structure that performs the function may be seen at the same time and the two properly associated. Students who see only prepared specimens can hardly avoid gaining the impression that the gorgeous red, blue and purple colors belong to the natural tissues, and would be so found in dissecting an animal. Indeed the histologist who studies his subject profoundly looks upon the adjuncts of stain, etc., as necessary evils at best, and he never feels quite sure that the appearances seen in these much-stained and manipulated specimens are true expressions of nature, or whether they are structures of his own creation (artifacts), until he has seen the appearances in the living substance, where the pitfalls of color and Canada

* The preparations used in my laboratory are the small ovarian ova found in the ovary of a young *Amblystoma*, or those left after spawning. All sizes are seen, giving also a hint that the different sizes mean the different crops of eggs, so to speak, that will reach maturity. The segmenting ova of *Amblystoma* are admirable for showing the blastula, and the formation of notochord and nervous system.

balsam have no place. (See the preface to *Foster and Langley's Practical Physiology.*)

5. All glands should be studied in various phases of their activity and repose, so that the structural features present in each phase may be associated with the functional condition. In a word it is greatly to the advantage of the student if the histology he studies is truly "Physiological Histology."

6. The student will gain a truer insight into the structure of the body if he understands at the beginning that every organ and every tissue as it is found in the body is really a complex, that is, it is composed of several tissues and of ground substance. For example, muscle is composed not only of the characteristic structural elements, the muscle fibers or cells, but mingled with these are connective tissue and blood vessels, and nerves are abundant. Even in epithelium the cells are not the whole of the tissue, for there is always present the cell cement uniting the cells. In connective tissue, the characteristic elements or cells, so prominent in this tissue in embryonic life, are so far pushed into the back-ground by the intercellular or ground substance, that the tissue is actually characterised, not by the cells, but by the ground substance. Thus we speak of cartilage, ligament and bone and the other members of the connective tissue group, having in mind almost altogether the intercellular substance, and not the cellular elements.

7. Of necessity, as well as preferably, every general course in histology must be a course in *comparative histology*, as structural details are not all shown with equal clearness in any one form and not obtainable at all or only with difficulty in some. For example, hair is not found below the mammals, and the fibrin network in the blood and lymph is far more satisfactory in man and the other mammals than in *Amphibia* and fishes, while nucleated red blood corpuscles are found with difficulty in mammals, while they are normal in non-mammals. As the course is then to be really one in *comparative histology*, the fact should be distinctly expressed, and the student not left to infer that a structural detail seen

in one animal would be found exactly similar in all others. On the other hand, it should be most emphatically brought out that *while there is unity in type there is much diversity in detail.* This can be demonstrated by each student in comparing the striated muscle of mammals and *Amphibia ;* or to take nearly related forms, the *ligamentum nuchæ* of the ox and other grazing forms is almost purely elastic tissue, while in the cat and man it is largely white fibrous tissue, and far less prominent. This point has been insisted upon because if any one looks through the pages of any work on histology, even though "human histology" may be printed on the title page, he will find it really a comparative histology, with the comparisons left out. That is, there will be figures of structures from widely differing animals to illustrate the structure of the different tissues, and frequently even the accompanying legend or explanation gives no hint that the tissue figured is not from man. Naturally the student concludes that the tissues are exactly alike in all animals. If on the other hand homologous parts from different animals are carefully compared many of them will show marked differences in detail, although the type of structure is unmistakable.

8. If it is necessary to keep in mind the differences in anatomic details in different animals, so is it equally important to know and to learn to demonstrate differences in structural detail of the same tissue or organ in the same animal in different phases of activity, in vigorous youth and in senile decay. Indeed, the differences in structural appearance of the pancreas, for example, before and after secretion, is as great as the apparent structural differences in quite widely differing forms. It is, therefore, necessary for a complete understanding of structural appearances to keep physiology constantly in mind ; and as so few animals are in perfect health, possible pathologic variations from the normal appearance must be looked out for, otherwise one might in a limited number of observations decide that merely temporary or even abnormal structural appearances were characteristic of the animal under investigation.

The above statements, while they apply to the study of histology in general, have special reference in the main to elementary courses, where the students are introduced to the subject and are naturally imbibing the spirit of the study.

The course outlined above would require considerable time. It could not be satisfactorily gone over in less than one college year in a course consisting of two lectures per week and three laboratory periods of two and one-half hours each.

For research in this, as in any other subject, there must be great liberty as well as good facilities for work and experimentation. Mistakes will be made and time apparently wasted; but the mistakes and the apparent waste of time are a part of the "dead work" that must be done by all those who aspire to perform truly advanced work and to add to the sum of human knowledge.

Besides the numerous addresses and special papers that have appeared the student and teacher will find the six books named below especially helpful and inspiring:

An American Text Book of Physiology. Edited by Wm. H. Howell, of Johns Hopkins. The writers besides the editor are: H. P. Bowditch, J. G. Curtis, H. H. Donaldson, F. S. Lee, W. P. Lombard, G. Lusk, W. T. Porter, E. T. Reichert and H. Sewall. Philadelphia. 1896.

Bernard, Claude, Cours de physiologie générale du Muséum d'histoire Naturelle. Leçons sur les phénomènes de la vie communs aux animaux et aux végétaux, two vols. Paris. 1878-1879.

Foster, M.—A text book of Physiology (1877 to 1896). London and New York. The sixth edition contains much histology. All the editions correlate structure and function in an admirable way.

Metchnikoff, Elias—Lectures on the comparative pathology of inflammation delivered at the Pasteur Institute in 1891. Translated from the French by F. A. and E. H. Starling, London. 1893.

Hertwig, O.—The Cell ; Outlines of General Anatomy and Physiology. Translated and edited by M. and H. J. Campbell. London and New York. 1895.

Wilson, E. B.—The Cell in Development and Inheritance. Columbia University Series IV. New York and London. 1896.

For an excellent article on "The Importance of Technical Instruction in our Medical College Laboratories," see Dr. A. P. Ohlmacher, *New York Medical Record*, Vol. LXIII., March 21, 1896, p. 374.

For a view that all microscopical and bacteriological knowledge is of no assistance in either medicine or biology, see Dr. Charles G. Kuhlman, in the *St. Louis Medical and Surgical Journal*, Vol. LXX. April, 1896, p. 201.

Addendum : Those who have the planning and execution of laboratory courses in histology will find many suggestions and much help in a paper by L. F. Barker and C. R. Bardeen in the Johns Hopkins Hospital Bulletin for May–June, 1896. It is entitled : "An outline of the course in Normal Histology and Microscopic Anatomy," and represents the course followed in the Johns Hopkins Medical School for the year 1895-1896.

THE PURPOSE OF THE NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION AND THE WORK IT HOPES TO ACCOMPLISH.

By Simon H. Gage.

From Science, March 19, 1897. Pp. 458–460.

It is a source of congratulation that the Science Teachers of the Empire State are no longer to remain scattered and unorganized, but by association are to gain the encouragement and enthusiasm which united effort brings. That enthusiasm and efficiency are promoted by such organization of science teachers is abundantly attested by the results gained through the efforts of the American Society of Naturalists, and the teachers of Illinois, Colorado, California, and of other sections.

An association like this makes it easier for the college and for the secondary school teacher to come together and talk over matters of mutual interest and concern. In these friendly consultations and discussions there will be a chance of finding out something of what is most desirable and what is practicable and possible in the schools each represents. And in these discussions it will not be possible to forget the children in the elementary schools, the great majority of whom come neither under the training of the high school nor of the college, but must be content to get the best they can from the elementary schools to equip them for the struggle of life which stands so near them. What help have these a right to ask from the high school and the college? And then the great world of thought and action whose mighty stream, sooner or later, draws all into it, what does it demand? It is, after all, the final court which tries all alike, and puts each to the test whether he be a college graduate, high school graduate, pupil of an elementary school or one who has only his heriditary endowment of mother wit.

The signs of the times all indicate that the high school teacher is to be at least a college graduate, and the elementary school teacher a high school graduate. If this is true, while the college has but few under its immediate instruction it determines the character of the high school, and in turn the high school determines the character of the elementary

school. The college is then the intellectual guide of the land. Is it and has it always been a wise and sympathetic guide?

If we compare our times with those of 500 or even 100 years ago there will be found an immense difference, and science is largely responsible for this difference. Whether we approve or not, things are not as they once were; whether we designate the change as one of progress or decline, there has been change, the world is not what it once was. The modern citizen must adapt himself to these changes or be ground to powder in the struggle for existence or for preëminence. The professional man, if he is a physician, is a criminal if he does not know and apply the science bearing upon his profession; and the lawyer who has only the knowledge that the Middle Ages might have given him is soon eliminated from the race. It is with hesitation that I speak of the clergyman, but if he misrepresents nature which he might know, and to which he so often reverts for illustration, how can he expect unhesitating acceptance of his words concerning the profound mysteries that all, even the most favored, must 'now see as through a glass darkly?' The artisan, farmer and business man cannot live as did their forefathers; and so from the professions, from all the people, there comes an appeal so earnest, so pressing, that we cannot choose but hear. If they suffer for lack of knowledge we must do our best to supply the knowledge. We should give them the science we possess, show them the way it is gained, and how much there is yet to be gained, and thus make every boy and girl, and through them every man and woman, in our great State an observer or original investigator in science. This can come about only when real science is taught and studied, only when baseless authority and the fog of opinion are brushed aside and the pupils in the schools are brought in direct contact with nature, and there learn to appreciate and apply the scientific method so admirably stated by St. Paul: "Prove all things, hold fast that which is good."

Our Association ought not and cannot stop with the work of the high school. From the elementary schools most pupils must enter the labors of life; they make the bulk of the State, and a noble patriotism should lead us to do all we can for them. On the principle of self-preservation also such help is wise, for the work of high school and college alike have their foundations laid in the elementary school. As the college reaches down to help and encourage the high school, so should the high school reach down and help and encourage the elementary school, and thus will it come about that every child in the State will be brought into direct contact with nature, where he can experience for himself her inspiring and uplifting sympathy.

If this program is to be carried out the college must train its students and prepare them to take the true science, science at first hand into the high school, and banish therefrom anything savoring of sham. Then the college must honor its graduates by accepting for entrance the work in science of the high school on equal terms with other subjects

taught by its graduates. To bring this about, I take it, is one of the duties of this Association. Thanks to the work of the American Society of Naturalists, and to the many able men and women who have worked for the same end, science work done in the high school is at the present moment recognized by a considerable number of colleges. See *Science*, December 25, 1896.

It is discouraging, almost prohibitive, for the college to say to the secondary school, when you reach the proper degree of excellence in your science work, the college will consider your appeal for recognition. Why cannot the college state fairly and explicitly exactly what the standard of excellence should be? and with equal fairness and justice say, when your students reach this standard we will accept them for entrance on the same terms as for other good preparatory work. No true friend of science would ask the college to admit students with a training in science inferior to that required in the older disciplines. Let the college make its standard as high as it will, but let it recognize the work that comes up to its standard, and thereby honor its own graduates who have so worthily brought the work of their pupils up to the high standard. Such recognition would put science on a fair footing with the other disciplines. It would encourage and inspire the teacher in the secondary schools and help to give his work a dignity and importance in the eyes of his pupils and colleagues which it can never have if it is not honored by the college. Men still respect and honor what the college approves, and it is a part of our work to see to it that the college puts the seal of its approval on sound learning in science as well as on that of the other disciplines which it accepts for entrance to its halls.

It seems to me the way before us is clear. Changed conditions have brought new needs, needs that knowledge of science can alone supply. We should do our best to help our day and generation, and in giving it the help of science and the sympathy of nature I feel confident that we are doing right in every way. Science, taught as every true teacher will teach it, will help the students to gain an insight into nature, will bring them face to face with reality, with law and order, and certainly will form at least one element in a noble education. It will emphasize the old lesson that power over nature comes only by obedience to her, and by this obedience, which can come only through understanding, discipline is gained. By action in accordance with law which is understood, and by reflection comes culture. With this discipline and culture come large sympathies and a wide outlook upon the universe. There comes also the consciousness that, while the current of life and law is irresistible, man is a part of the mighty current and his will has its due share in directing it.

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NOTES ON THE ISOLATION OF THE TISSUE ELEMENTS.

SIMON H. GAGE, Ithaca, N. Y.

In the present period when the technique of section cutting has become so perfect that many of the cells of the body may be cut into several pieces, there is some danger of losing sight of the actual conformation of the cells as wholes. Certainly, as teachers of histology, it is desirable for us to show our students as many of the cells or tissue elements as possible so that they may realise that the teacher is discussing, real, tangible entities when he speaks of epithelial cells, muscle cells or brain cells, and the like. Furthermore, the student should gain an allround conception, so to speak, and this notion of the tissue elements is gained by the student only when he can see all around the structures; this feat is easily accomplished in the isolated cells by causing them to roll over with a little pressure on the cover-glass.

In dissociating, the aim is to separate the tissue elements from one another, the cells and all their minute processes being preserved in their true form. In order to do this the cell-cement, or intercellular substance, must be dissolved or softened. The perfect dissociator then, must harden the tissue elements and soften the substance which holds them together. Many excellent dissociators have been described. None will serve equally well for all tissues, and there may be a "best dissociator" for each animal; it seemed worth while, however, to present a note upon the results of an extended series of experiments to discover if possible the general and underlying principles.

The general principles seem to be these : *Any agent which acts as a good hardening and fixing medium for a tissue will also serve for a dissociating substance if sufficiently diluted and allowed to act only a short time.* So far as experiments have gone it was found that if the fixer suitable for a tissue were diluted ten times and allowed to act from two hours to two days, good results were obtained in isolating. It was further found that if the diluting substance used were normal salt solution (water 1000 cc., common salt 6 grams,) the results were, perhaps, more satisfactory. This use of normal salt solution was suggested from the fact that it tends to leave the tissues without change, and the diffusion currents are not so severe as when water alone is used for dilution.

For the epithelia of mucous and serous surfaces nothing was found so satisfactory for all animals as formaldehyde in normal salt solution. The strength used was 2 cc. in a liter of normal salt solution. For many epithelia the isolation may be considered sufficient in one to two hours ; good preparations from the same may be got after a day or two. This dissociator is excellent for obtaining the ciliated cells of the brain ventricles. And in experimenting with it for that purpose it was found that the nerve cells of the cerebral cortex were most satisfactorily isolated also. For one who has only seen nerve cells in sections it would be a revelation to see the processes as shown in such isolation preparations, and then if the cells be made to roll over, it will be seen that the cells have processes projecting from every side.

No method of studying the isolated elements has been so successful as scraping off a small mass and mounting on a slide in the dissociating medium, and then for the more complete separation the cover-glass is gently hammered over the mass of cells. The mechanical jarring separates the cells without tearing them, and often two or more cells are just sufficiently separated to show their mutual relation. It is sometimes advantageous to add a little eosin solution to the

mass of cells before mounting or after, but as the mounting medium, if the dissociator is used, is of such different refractive index, all the structural details come out without stains; and it is worth while to let the student see that histological structure can be seen under the microscope without gorgeous stains. He will then know, which I fear is not always the case now, that the cells are not red and purple in the living body.

If in examining preparations mounted only in the dissociator one should meet with something that he was extremely desirous of preserving, the slide may be laid flat and a drop of glycerin put at the edge of the cover. It will partly diffuse and also as the dissociator evaporates it will run in by capillarity and in a few days the preparation will be mounted in glycerin. It may then be sealed with shellac or other cement and will last a reasonable length of time, that is, till one naturally gets a better preparation to take its place.

If one wishes to have the cells stained for the permanent preparations, instead of using glycerin alone, as just described, the following mixture will be found excellent: Glycerin, 85 c.c.; alum carmine, $7\frac{1}{2}$ c.c.; eosin, $\frac{1}{2}$ per cent. aqueous solution, $7\frac{1}{2}$ c.c. This may be put at the edge of the cover as for the glycerin, or preferably it should be mixed with the cells before putting on the cover-glass. The alum carmine stains the nuclei and the eosin the cell body.

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Platinum Chlorid for Demonstrating the Fibrils of Striated Muscle.

SIMON HENRY GAGE.

Since the great monograph of Bowman* on the structure of muscle, the fundamental facts presented by him still are the ones represented in the best modern text-books, although in some details there has of course been considerable modification.

If one consults this monograph, or a later monograph or book on the histology of muscle, one can but be impressed with the fact that there is a great preponderance of discussion upon the structure in lower forms, insects, fishes, and amphibia. This is true, although the book may be entitled "Human Histology."

If one seeks for methods to demonstrate the various appearances figured and described, it will be found that it frequently requires days, weeks, or even months, to get the preparations ready for study. For the investigator who is carrying on several pieces of work at the same time, this may not be a drawback; but in the case of the teacher with classes having but a limited time for work, he must prepare material a long time in advance, and thus the students be deprived of the actual personal experience which they can alone obtain by taking every step themselves, or some method must be devised which shall be both certain and rapid. Owing to the constant effort of laboratory teachers, every year adds to the list of such rapid and excellent methods. In my own field, where mammalian histology and embryology are of principal importance for my laboratory students, there is a constant effort to find methods applicable to such animals in the published accounts of others and by personal experiments. So much effort is made because, while the type may be the same in different animals, the details of structure are often markedly different in the different forms, and it seems hardly fair to students to show them only insect muscle, for example, and lead them to assume that the appearances are exactly the same in mammals.

In studying the tissues of animals, one of the greatest needs is some means of isolating the cells or structural elements so that details of form and structure may be made out with certainty, and the confusion arising from overlying or underlying cells avoided. While making a series of experiments on different media for dissociation, it was found that platinum chlorid in a one-tenth per cent. aqueous solution (platinum chlorid 1 gram, water 1000cc.), acting from two to twenty-four hours, gave most beautiful preparations of the longitudinal striation and the fibrils of mammalian muscle. In many cases, if the teasing was thorough, the fibers appeared like a skein of thread, and frequently the fibrils were detached from the bundle, thus affording opportunity for their special study.

The method has been applied to mammals (man, horse, dog, cat, sheep, rabbit, guinea pig), amphibia, fishes, insects, and cray-fish. It is well adapted to all, but more especially to the mammalian muscle, where the demonstration of fibrils and longitudinal striation is more difficult or requires more time than in the lower forms.†

In practice about five times as much liquid is taken as muscle, and the piece of muscle should not be larger than one's little finger. Very small pieces should be worked on within a few hours, two to five, while larger pieces may wait longer. That is there is too great hardening of the tissue if the solution acts on a small mass for a considerable time. For a simple, temporary demonstration a shred or fascicle is removed from the mass of muscle and teased out in water or in some of the dissociating liquid, but if one wishes to demonstrate the finest details, and to see with clearness the various discs described in modern works he should proceed as follows: A small fascicle is teased very thoroughly in a drop of water. One may use a tripod magnifier to make sure that the teasing is thorough. The water is drained off and two or three drops of a two per cent. solution of erythrosin in fifty per cent. alcohol is added and left for five minutes; or one may use a two per cent. aqueous solution of eosin. Either of these agents will stain the parts of the fibrils which appear dark in unstained preparations,

*Phil. Trans. 1840-41, pp. 457-501, 4 plates.

†Many good dissociators for special purposes have been devised, but so far as I know there has been no generalization of the fundamental principles which would serve as a guide in case one had not access to the special liquid described. In a series of experiments to see if there was not some underlying principle, the writer came to the conclusion that, while a given detail of structure or a given kind of cells might be more clearly demonstrated by one method than by another, yet the generalization seemed justified that "Any medium which fixes a tissue well may be used to isolate its structural elements if employed in a proper dilution (about one-tenth the strength used in fixing) and allowed to act only a limited time—two to twenty-four hours. See "Proceedings of the Amer. Micr. Soc. for 1897.") It was in this series of experiments, made three years ago, that the special excellence of platinum chlorid for demonstrating the longtitudinal striation and fibrils of muscle was discovered.

but the erythrosin is preferable. After five minutes the stain is poured off carefully, and the fibers are washed with several drops of water and then dehydrated with 95 per cent. or stronger, alcohol (two or three pipettes full will suffice). A drop of clearer (carbol-turpentine or carbol-xylene) is added after pouring off the alcohol, and the fibers are carefully separated with needles, and after pouring off the clearer a cover spread with balsam is put over them. If the preparation is successful, and most of them are, one gets a very satisfactory view of the minute structure as well as of the general structure, as some of the fibers will show with perfection the transverse striae, others the longitudinal striae and the isolated fibrils. For seeing the minute details, a good homogeneous immersion objective and careful lighting are necessary.

If a muscle is found to give good preparations it may be preserved for at least three years in fifty per cent. alcohol and give good results.

TEACHER'S LEAFLETS.

FOR USE IN THE PUBLIC SCHOOLS.

PREPARED BY

No. 9.

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I. P. ROBERTS, DIRECTOR.

The Life History of the Toad.

BY SIMON HENRY GAGE.*

The life-history of the common or warty toad has been selected for various reasons as the subject of a leaflet in nature study: This history is exceedingly interesting. The marvelous changes passed through in growing from an egg to a toad are so rapid that they may all be seen during a single spring term of school. Toads are found everywhere in New York, and nearly everywhere in the world; it is easy, therefore, to get abundant material for study. This animal is such a good friend to the farmer, the gardener, the fruit grower, the florist and the stock raiser that every man and woman, every boy and girl ought to know something about it, and thus learn to appreciate their lowly helper.

And finally, it is hoped and sincerely believed that the feeling of repugnance and dislike, and the consequent cruelty to toads, will disappear when the children know something about their wonderful changes in form, structure and habits, and how harmless and helpful they are. Then who that knows of the chances, the dangers and struggles in the life of the toad, can help a feeling of sympathy; for after all, how like our human life it is.

*It was the desire of the author to tell the story of this leaflet in pictures as well as in words, and he wishes to express his appreciation of the enthusiasm and ability with which the illustrations were executed by Mr. C.W. Furlong.

Where sympathy is, cruelty is impossible, and one comes to feel the spirit of these beautiful lines from Coleridge's "Ancient Mariner:"

"He prayeth best who loveth best
All things both great and small;
For the dear God who loveth us
He made and loveth all."

It was William Harvey, the discoverer of the circulation of the blood, who first clearly stated to the world the fact that every animal comes from an egg. This is as true of the toad as of a chicken. The toad lives on the land and often a long way from any pond or stream, but the first part of its life is spent in the water; and so it is in the water that the eggs must be looked for.

To find the eggs one should visit the natural or artificial ponds so common along streams. Ponds from springs or even artificial reservoirs or the basins around fountains may also contain the eggs. The time for finding the eggs depends on the season. The toad observes the season, not the almanac. In ordinary years the best time is from the middle of April to the first of May. One is often guided to the right place by noticing the direction from which the song or call of the toad comes. It may be said in passing that toad choirs are composed solely of male voices. The call is more or less like that of tree toads. In general it sounds like whistling, and at the same time pronouncing deep in the throat bu–rr–r–r–r–. If one watches a toad while it makes its call, he can soon learn to distinguish the sound from others somewhat similar. It will be found that different toads have slightly different voices, and the same one can vary the tone considerably, so that it is not so easy after all to distinguish the many batrachian solos and choruses on a spring or summer evening. It will be noticed that the toad does not open its mouth when it sings, but there is a great, expansible, vocal sack or resonator under the mouth and throat (see the left hand toad in the plate).

The eggs are laid in long strings or ropes which are nearly always tangled and wound round the water plants or sticks on the bottom of the pond near the shore. If the eggs have been freshly laid or if there has been no rain to stir up the mud and the

The toad in various stages of development from the egg to the adult.

water is clear, the egg ropes will look like glass tubes containing a string of jet black beads. After a rain the eggs are obscured by the fine mud that settles on the transparent jelly surrounding them.

Take enough of the egg string to include 50 or 100 eggs, and place it in a glass fruit dish or a basin with clean water from the pond where the eggs were found. Let the children look at the eggs very carefully and note the color and the exact shape. Let them see if the color is the same on all sides. If the eggs are newly laid they will be nearly perfect spheres.

Frogs, salamanders and tree toads lay their eggs in the same places and at about the same time as the toad we are to study. Only the toad lays its eggs in strings so one can be sure he has the right kind. The others lay their eggs in bunches or singly on the plant so they never need be mistaken for the ones sought.

The eggs which are taken to the school house for study should be kept in a light place, but not very long in the hot sun, for that would heat the water too much and kill the eggs.

It takes only a short time for the eggs to hatch. In warm weather two or three days are usually sufficient. As the changes are so very rapid, the eggs ought to be carefully looked at two or three times a day to make sure that all the principal changes are seen. If a pocket lens or a reading glass is to be had it will add to the interest, as more of the details can be observed. But good sharp eyes are sufficient if no lens is available.

Hatching.—Watch and see how long it is before the developing embryos commence to move. Note their change in form. As they elongate they move more vigorously till on the second or third day they wriggle out of the jelly surrounding them. This is hatching, and they are now free in the water and can swim about. It is curious to see them hang themselves up on the old egg string or on the edge of the dish. They do this by means of a peculiar v-shaped organ on their heads.

How different the little creatures are, which have just hatched, from the grown up toad which laid the eggs. The difference is about as great as that between a caterpillar and a butterfly.

Tadpoles, polliwogs.—We do not call the young of the frog, the

toad, and the tree toad, caterpillars, but tadpoles or polliwogs. The toad tadpoles are blacker than any of the others.

The tadpoles will live for some time in clear water with apparently nothing to eat. This is because the mother toad put into each egg some food, just as a hen puts a large supply of food within the egg shell to give the chicken a good start in life. But when the food that the mother supplied is used up the little tadpoles would die if they could not find some food for themselves. They must grow a great deal before they can turn into toads, and just like children and other young animals, to grow they must have plenty of food.

Feeding the tadpoles.—To feed the tadpoles it is necessary to imitate nature as closely as possible. To do this a visit to the pond where the eggs were found will give the clue. Many plants are present, and the bottom will be seen to slope gradually from the shore. The food of the tadpole is the minute plant life on the stones, the surface of the mud, or on the outside of the larger plants. Make an artificial pond in a small milk pan or a large basin or earthen-ware dish. Put some of the mud and stones and small plants in the dish, arranging all to imitate the pond, that is, so it will be shallow on one side and deeper on the other. Take a small pail of clear water from the pond to the school house and pour it into the dish to complete the artificial pond. The next morning when all the mud has settled and the water is clear, put 30 or 40 of the little tadpoles which hatched from the egg string, into the artificial pond. Keep this in the light, but not very long at any one time in the sun. The children may think this is not imitating nature, because the natural pond is in the full sunlight all day. The teacher can easily make them remember that the natural pond is on the cool earth where it cannot get very hot; but the small artificial pond might readily get very warm if left long in the hot sun.

One must not attempt to raise too many tadpoles in the artificial pond or there will not be enough food, and all will be half starved. While there may be thousands of tadpoles in the natural pond, it will be readily seen that, compared with the amount of water present, there are really rather few.

Probably many more were hatched out in the school-house

than can be raised in the artificial pond. Return the ones not put in the artificial pond to the natural pond. It would be too bad to throw them out on the ground to die.

Comparing the growth of the tadpoles.—Even when one does his best it is hard to make an artificial pond so good for the tadpoles as the natural one; and the teacher will find it very interesting and stimulating to compare the growth and change in the tadpoles at the school-house with those in the natural pond.

As growth depends on the supply of food and the suitability of the environment, it is easy to judge how nearly the artificial pond equals the natural pond for raising tadpoles. It will be worth while to take a tadpole from the natural pond occasionally and put it in with those at the school house so that the differences may be more strikingly shown. There is some danger in making a mistake here, however, for there may be three or four kinds of tadpoles in the natural pond. Those of the toad are almost jet black, while the others are more or less brownish. If one selects only the very black ones they will probably be toad tadpoles.

Every week or oftener, a little of the mud and perhaps a small stone covered with the growth of microscopic plants, and some water should be taken from the pond to the artificial pond. The water will supply the place of that which has evaporated, and the mud and the stone will carry a new supply of food.

The growth and changes in form should be looked for every day. Then it is very interesting to see what the tadpoles do, how they eat, and any signs of breathing.

All the changes from an egg to a little toad (see the plate,, are passed through in about two months, so that by the first of June the tadpoles will be found to have made great progress. The progress will be not only in size, but in form and action.

One of these actions should be watched with especial care for it means a great deal. At first the little tadpoles remain under water all the time, and do not seem to know or care that there is a great world above the water. But as they grow larger and larger, they rush up to the surface once in awhile and then dive down again as if their lives depended on it. The older they grow the oftener do they come to the surface. What is the meaning

of this? Probably most of the pupils can guess correctly; but it took scientific men a long time to find out just why this was done. The real reason is that the tadpole is getting lungs, and getting ready to breathe the free air above the water when it turns into a toad and lives on the land. At first the little tadpoles breathe the air dissolved in the water just as a fish does. This makes it plain why an artificial pond should have a broad surface exposed to the air. If one should use a narrow and deep vessel like a fruit jar, only a small amount of air could be taken up by the water and the tadpoles would be half suffocated.

As the tadpoles grow older their lungs develop more and more and they go oftener to the surface to get the air directly from the limitless supply above the water. They are getting used to breathing as they will have to when they live wholly in the air.

Disappearance of the tail.—From the first to the middle of June the tadpoles should be watched with especial care, for wonderful things are happening. Both the fore and hind legs will appear, if they have not already. The head will change in form and so will the body; the color will become much lighter, and, but for the tail, the tadpole will begin to look quite like its mother.

If you keep an especially sharp look out do you think you will see the tail drop off? No, toad nature is too economical for that. The tail will not drop off, but it will be seen to get shorter and shorter every day; it is not dropping off but is being carried into the tadpole. The tail is perfect at every stage; it simply disappears. How does this happen? This is another thing that it took scientific men a long time to find out. It is now known that within the body there are many living particles that wander about as if to see that everything is in order. They are called wandering cells, white blood corpuscles, phagocytes and several other names. These wander into the tail at the right time and take it up particle by particle. The wandering cells carry the particles of tail into the body of the tadpole where they can be made use of as any other good food would be. This taking in of the tail is done so carefully that the skin is never broken, but covers up the outside perfectly all the time. Is not this a better way to get rid of a tail than to cut it off?

Beginning of the life on the land.—Now when the legs are

grown out, and the tail is getting shorter, the little tadpole likes to put its nose out of the water into the air ; and sometimes it crawls half way out. When the tail gets quite short, often a mere stub, it will crawl out entirely and stay for some time in the air. It now looks really like a toad except that it is nearly smooth instead of being warty like its mother, and is only about as large as the end of one's little finger.

Finally the time comes when the tadpole, now transformed into a toad, must leave the water for the land.

What queer feelings the little toad must have when the soft, smooth bottom of the pond and the pretty plants, and the water that supported it so nicely are all to be left behind for the hard, rough, dry land. But the little toad must take the step. It is no longer a tadpole, or half tadpole and half toad. It cannot again dive into the cool, soft water when the air and the sunshine dry and scorch it. As countless generations of little toads have done before, it pushes boldly out over the land and away from the water.

If one visits the natural pond at about this season (last half of June, first of July), he is likely to see many of the little fellows hopping away from the water. And so vigorously do they hop along that in a few days they may be as far as a mile from the pond where they were hatched. After a warm shower they are particularly active, and are then most commonly seen. Many think they rained down. " They were not seen before the rain, so they must have rained down." Is that good reasoning ?

While the little toad is very brave in its way, it is also careful and during the hot and sunny part of the day stays in the shade of the grass or leaves or in some other moist and shady place. If it were foolish as well as brave it might be filled with vanity and stay out in the sun till it dried up.

Food on the Land.

In the water the tadpole eats vegetable matter, but when it becomes a toad and gets on the land it will touch nothing but animal food, and that must be so fresh that it is alive and moving. This food consists of every creeping, crawling or flying thing that is small enough to be swallowed. While it will not

touch a piece of fresh meat, woe to snail insect or worm that comes within its reach.

It is by the destruction of insects and worms that the toad helps men so greatly. The insects and worms eat the grain, the fruits and the flowers. They bite and sting the animals and give men no end of trouble. The toad is not partial, but takes any live thing that gets near it whether it is caterpillar, fly, spider, centipede or thousand legged worm; and it does not stop even there, but will gobble up a hornet or a yellow jacket without the least hesitation.

Toad catching a winged insect, and illustrating how the tongue is extended and brought in contact with the insect. Several other creatures that the toad might eat are shown in various parts of the picture.

It is astonishing to see the certainty with which a toad can catch these flying or crawling things. The way the toad does this may be observed by watching one out of doors some summer evening or after a shower; but it is more satisfactory to have a nearer view. Put a large toad into a box or into a glass dish with some moist sand on the bottom, and put the dish in a cool shady place so that the toad will not become overheated. In a little while, if one is gentle, the toad will see that it is not going to be hurt, and then if flies and other insects are put into the dish and the top covered with mosquito netting one can watch the process of capture. It is very quickly accomplished, and one must look sharply. As shown in the little picture on this page the toad's tongue is fastened at the front part of it's month, not back in the throat as with men, dogs, cats and most animals. It is so nicely arranged that it can be extended for quite a distance. On it is a sticky secretion, and when, quick as a flash, the tongue is thrown out or extended, if it touches the insect, the insect is caught as if by sticky fly paper, and is taken into the mouth. (See the picture.)

Think how many insects and worms a toad could destroy in a single summer. Practically every insect and worm destroyed adds to the produce of the garden and the farm, or takes away one cause of discomfort to men and animals. One observer

Toad making a meal of an angle worm.

roports that a single toad disposed of twenty-four caterpillars in ten minutes, and another ate thirty-five celery worms within three hours. He estimates that a good sized toad will destroy nearly 10,000 insects and worms in a single summer.

Enemies—The Shadow Side of Life.

So far nothing has been said about the troubles and dangers of the toad's life. The large plate at the beginning is meant to show the main phases in the life-history. If one looks at it per-

A couple of Newts feasting on tadpoles.

haps he may wonder what becomes of all the tadpoles that first hatch as only two toads are shown at the top. Is not this something like the human life-history? How many little children die and never become men and women! Well, the dangers to the

toad begin at once. Suppose the eggs are laid in a pond that dries up before the little toads can get ready to live on the land; in that case they all die. The mother toads sometimes do make the mistake of laying the eggs in ponds that dry up in a little while. You will not let the artificial pond at the school house dry up will you? Then sometimes there is an especially dry summer, and only those that transform from tadpoles to toads very early are saved.

In danger from a bird of prey.

In the little picture on page 88 is shown another source of danger and cause for the diminution in numbers. The newts and salamanders find young tadpoles very good eating and they make way with hundreds of them. Some die from what are called natural causes, that is diseases, or possibly they eat something that does not agree with them. So that while there were multitudes of eggs (1,000 or more from each toad), and of just hatched tadpoles, the number has become sadly lessened by the time the brood is ready to leave the water.

Then when they set foot on land,

Snakes usually, if not always, swallow toads hind legs foremost, as shown in the picture.

their dangers are not passed. They may be parched by summer's heat or crushed under the feet of men or cattle. Birds and snakes like them for food. The pictures on p. 89 show some of these dangers. Is it a wonder, then, that of all the multitudes of tadpoles so few grow up to be large toads?

We have so few helpers to keep the noxious insects in check, it is not believed that any boy or girl who knows this wonderful story of a toad's life will join the crows, the snakes and the salamanders in worrying or destroying their good friends.

Moulting and Hibernation.

There are two very interesting things that happen in the life of many of the lower animals; they happen to the toad also. These are moulting, or change of skin, and hibernation or winter sleep. Every boy and girl ought to know about these, and then, if on the lookout, they will sometime be seen.

Moulting.—Probably everybody who lives in the country has seen a snake's skin without any snake in it. It is often very perfect. When the outside skin or cuticle of a snake or a toad gets old and dry or too tight for it, a new covering grows underneath, and the old one is shed. This is a very interesting performance, but the toad usually does it in a retired place, so it is not often seen. Those who have seen it say that a long crack or tear appears along the back and in front. The toad keeps moving and wriggling to loosen the old cuticle. This peels the cuticle off the sides. Now to get it off the legs and feet, the toad puts its leg under its arm, or front leg, and in that way pulls off the old skin as if it were a stocking. But when the front legs are to be stripped, the mouth is used as is sometimes done by people in pulling off their gloves. Do you think it uses its teeth for this purpose? You might look in a toad's mouth sometime and then you would know.

It is said that when the skin is finally pulled off the toad swallows it. This is probably true in some cases, at least it is worth while keeping watch for. After a toad has shed his old skin, he looks a great deal brighter and cleaner than before, as if he had just got a new suit of clothes. If you see one with a particularly bright skin you will now know what it means.

Hibernation.—The toad is a cold-blooded animal. This means that the temperature of its blood is nearly like that of the surrounding air. Men, horses, cows, dogs, etc., are said to be warm blooded, for their blood is warm and of about the same temperature whether the surrounding air is cold or hot.

When the air is too cool the toad gets stupid and inactive. In September and October, a few toads may be seen on warm days or evenings, but the number seen becomes smaller and smaller; and finally as the cold November weather comes on, none are seen. Where are they? The toad seems to know that winter is coming, that the insects and worms will disappear so that no food can be found. It must go into a kind of death-like sleep in which it hardly moves or breathes. A toad is sensible enough to know that it will not do to go into this profound sleep except in some safe and protected place. If it were to freeze and thaw with every change in the weather it would not wake up in the spring.

The wonderful foresight which instinct gives it, makes the toad select some comparatively soft earth in a protected place where it can bury itself. The earth chosen is moist, but not wet. If it were dry, the toad would dry up before spring. It is not uncommon for farmers and gardeners to plough them up late in the fall or early in the spring. Also in digging cellars at about these times, they are found occasionally.

It is very interesting to see a toad bury itself. If one is found hibernating in the fall, or if one is found very early in the spring on some cold day after a warm spell, the process can very easily be seen. Put some loose earth in a box or a glass dish and put the toad on the top of the earth. It will be found that the toad digs backwards, not forwards. It digs with its hind legs and body, and pushes itself backward into the hole with the front legs. The earth caves in as the animal backs into the ground so that no sign is left on the outside. Once in far enough to escape the freezing and thawing of winter the toad moves around till there is a little chamber slightly larger than its body; then it draws its legs up close, shuts its eyes, puts its head down between or on its hands, and goes to sleep and sleeps for five months or more.

When the warm days of spring come it wakes up, crawls out of bed and begins to take interest in life again. It looks around for insects and worms, and acts as if it had had only a comfortable nap.

The little toad that you saw hatch from an egg into a tadpole and then turn to a toad, would hibernate for two or three winters, and by that time it would be quite a large toad. After it had grown up and had awakened from its winter sleep some spring, it would have a great longing to get back to the pond where it began life as an egg years before. Once there it would lay a great number of eggs, perhaps a thousand or two for a new generation of toads. And this would complete its life cycle.

While the toad completes its life cycle when it returns to the

water and lays eggs for a new generation, it may live many years afterward and lay eggs many times, perhaps every year.

Many insects, some fish and other animals die after laying their eggs. For such animals the completion of the life cycle ends the life-history also. But unless the toad meets with some accident it goes back to its land home after laying the eggs, and may live in the same garden or door yard for many years, as many as eight years and perhaps longer. (See Bulletin No. 46, Hatch Experiment Station of the Massachusetts Agricultural College, Amherst, Mass.)

Erroneous Notions About the Toad.

If one reads in old books and listens to the fairy tales and other stories common everywhere, he will hear many wonderful things about the toad, but most of the things are wholly untrue.

One of the erroneous notions is that the toad is deadly poison. Another is that it is possessed of marvelous healing virtues, and still another, that hidden away in the heads of some of the oldest ones, are the priceless toad-stones, jewels of inestimable value.

Giving warts.—Probably every boy and girl living in the country has heard that if one takes a toad in his hands, or if a toad touches him anywhere he will "catch the warts." This is not so at all, as has been proved over and over again. If a toad is handled gently and petted a little, it soon learns not to be afraid, and seems to enjoy the kindness and attention. If a toad is hurt or roughly handled, a whitish, acrid substance is poured out of the largest warts. This might smart a little if it got into the mouth, as dogs find out when they try biting a toad. It cannot be very bad, however, or the hawks, owls, crows and snakes that eat the toad would give up the practice. The toad is really one of the most harmless creatures in the world, and has never been known to hurt a man or a child.

A boy might possibly have some warts on his hands after handling a toad; so might he after handling a jack-knife or looking at a steam engine; but the toad does not give the warts any more than the knife or the engine.

Living without air and food.—Occasionally one reads or hears a story about a toad found in a cavity in a solid rock. When the rock is broken open, it is said that the toad wakes up and hops around as if it had been asleep only half an hour. Just think for a moment what it would mean to find a live toad within a cavity in a solid rock. It must have been there for thousands, if not for millions of years without food or air. The toad does not like a long fast, but can stand it for a year or so without food

if it is in a moist place and supplied with air. It regularly sleeps four or five months every winter, but never in a place devoid of air. If the air were cut off the toad would soon die. Some careful experiments were made by French scientific men, and the stories told about toads living indefinitely without air or food were utterly disproved.

It is not difficult to see that one working in a quarry might honestly think that he had found a toad in a rock. Toads are not very uncommon in quarries. If a stone were broken open and a cavity found in it, and then a toad were seen hopping away, one might jump at the conclusion that the toad came out of the cavity in the rock. Is not this something like the belief that the little toads rain down from the clouds because they are most commonly seen after a shower?

Surveys and Maps.

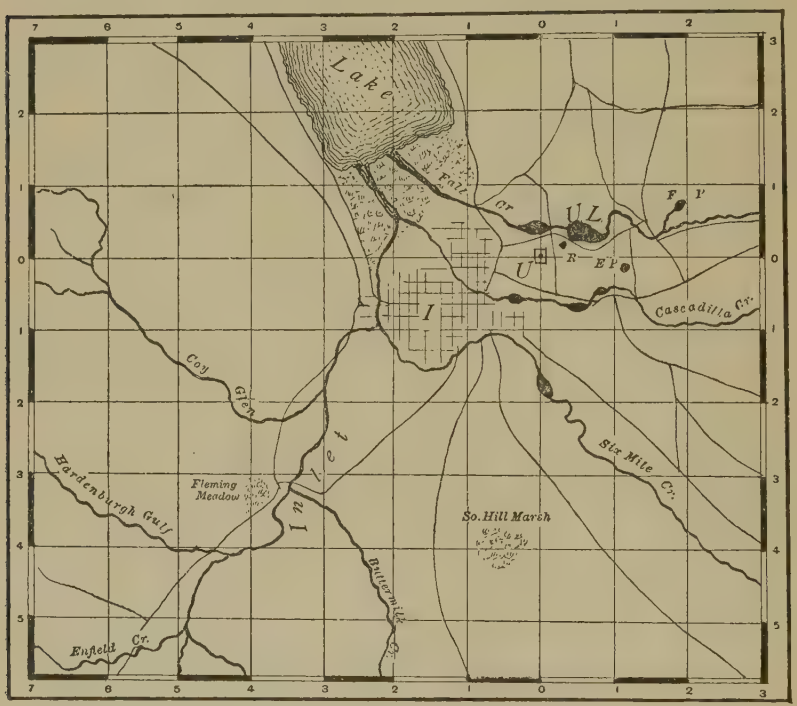
In considering the suggestions made in this leaflet, we thought of the hundreds of schools throughout the state and wondered if there might not be some difficulty in finding the ponds where the toads lay their eggs, and in finding some of the things described in the other leaflets.

The teachers and students in Cornell University found this difficulty twenty-eight years ago when the University opened. The great Louis Agassiz came to the University at the beginning to give a course of lectures on nature study. The inspiration of his presence and advice, and of those lectures lasts to this day.

Agassiz, and the University teachers, who had many of them been his pupils, saw at once that the region around Ithaca must be full of interesting things; but they did not know exactly where to find them. Agassiz himself made some explorations, and the professors and students took hold of the work with the greatest enthusiasm. They explored the beautiful lake, the streams, hills, valleys, gorges, ponds and marshes. Careful notes were kept of the exact locality where every interesting thing was found; and simple maps were made to aid in finding the places again. Finally, after several years, knowledge enough was gained to construct an accurate map for the use of all. A part of this map, showing only the most important features, is put into this leaflet to serve as a guide.

It will be seen that the University is made the central or start-

ing point. With a few hints it is believed that every school can make a good beginning this year on a natural history survey of the region near their schoolhouse, and in the preparation of a map to go with the survey.



Simple map showing the position of Cornell University, the city of Ithaca, Cayuga Lake, and the roads and streams and ponds near the University. From W. R. Dudley's map in "The Cayuga Flora." Scale, 1 centimeter to the kilometer.

U. Cornell University.

U. L. University Lake in Fall Creek.

R. Reservoir supplied from University lake, and supplying the campus.

E. P. East Pond where the eggs of the toad, tree toad, frogs and salamanders are found.

F. P. Forest Home Pond. A very favorable place for eggs, tadpoles, etc.

Inlet. The inlet of the lake. The lampreys are abundant near Fleming's meadow.

Preparation of the map.—It is well to have the map of good size. A half sheet of bristol board will answer, but a whole sheet is better. About the first thing to decide is the scale at which the map is to be drawn. It is better to have the scale large. Twelve inches to the mile would be convenient. Divide the map into squares, making the lines quite heavy. If so large a scale were used it would be advantageous for locating places to have the large squares divided into square inches, but much lighter lines should be used so that there will be no confusion with the lines representing the miles.

Locating objects on the map.—The corner of the school-house containing the corner stone should be taken as the starting point. If there is no corner stone, select the most convenient corner. Put the school-house on the map anywhere you wish, probably the center of the map would be the best place. In the sample map the university is not in the center as it was desired to show more of the country to the south and west than to the north and east.

The map should of course be made like other maps, so it will be necessary to know the four cardinal points of the compass before locating anything on it. Perhaps the school-house has been placed facing exactly north and south or east and west, that is arranged with the cardinal points of the compass ; if so it will be the best guide. If you are not sure determine with a compass. With it the points can be determined quite accurately. Having determined the points of compass, commence to locate objects in the landscape on the map as follows : Get their direction from the starting point at the corner of the school-house, then measure the distance accurately by running a bicycle on which is a cyclometer, straight between the starting point and the object. The cyclometer will record the distance accurately and it can be read off easily. If no bicycle with a cyclometer is available one can use a long measuring stick, a tape measure or even a measured string ; but the bicycle and cyclometer are more convenient and accurate, especially when the distances are considerable.

Suppose the distance is found to be one-sixth of a mile due west. It should be located two inches west of the corner taken as the starting point. If the direction were south-west then the

two inches would be measured on the map in that direction and located accordingly. Proceed in this way for locating any pond or marsh, forest or glen. Now, when the places are located on the map, you can see how easy it would be for any one to find the places themselves. While the exact position should be determined if possible and located, one does not often take a bee-line in visiting them, but goes in roads, often a long distance around. In locating the objects on the map every effort should be made to get them accurately placed, and this can only be done by knowing the distances in a straight line.

It is hoped that every school in the state will begin making a natural history survey and a map of the region around its school house this year. The map will show but few locations perhaps, but it can be added to from year to year, just as the University map has been added to; and finally each school will have a map and notes showing exactly where the toads lay their eggs, where fish and birds are; and where the newts and salamanders, the different trees and flowers, rocks and fossils may be found.

If the dates are kept accurately for the different years one can also see how much variation there is. Indeed such nature study will give a sure foundation for appreciating and comprehending the larger questions in natural science, and it will make an almost perfect preparation for taking part in or for appreciating the great surveys of a state or a country. It is believed that if accurate information were collected and careful maps made by the different schools, the Empire State could soon have a natural history survey and map better than any in the world.

To the Teacher:

It is the firm belief of those who advocate "Nature Study" that it is not only valuable in itself, but that it will help to give enjoyment in other studies and meaning to them. Every pupil who follows out the work of this leaflet will see the need of a map of the region around the schoolhouse. This will help in the appreciation of map work generally.

So many of the beautiful and inspiring things in literature are concerning some phase of nature, that "Nature Study" must increase the appreciation of the literature, and the noble thoughts in the literature will help the pupils to look for and appreciate the finer things in nature.

It is suggested that as many of the following selections as possible be read in connection with the leaflet:

"The Fiftieth Birthday of Agassiz," by Longfellow; The "Prayer of Agassiz," by Whittier. (This describes an actual occurrence.)

The first part of Bryant's "Thanatopsis," Coleridge's "Ancient Mariner," Burns' "On scaring some water fowl in Loch-Turit" and "To a Mouse."

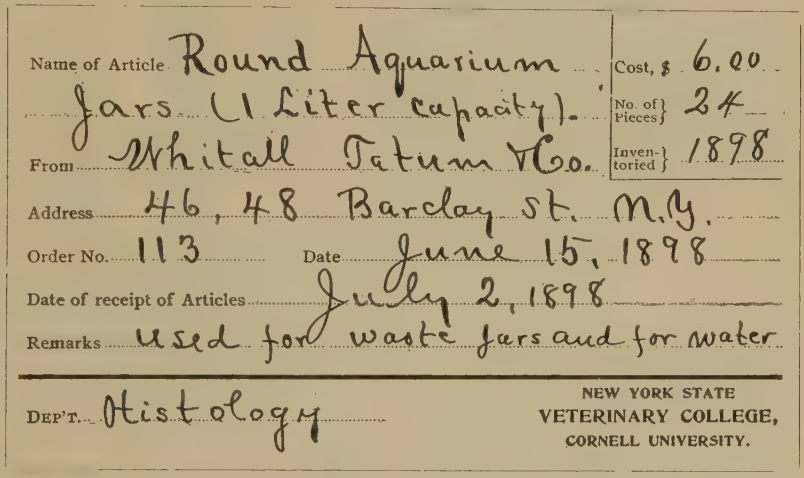
Cowper's "The Task," a selection from book vi., commencing with line 560. This gives a very just view of the rights of the lower animals. Kipling's Jungle stories will help to give an appreciation of the world from the standpoint of the animals.

In connection with the disappearance of the tail, read Lowell's "Festina Lente," in the Biglow Papers. For older pupils, Shakespeare's picture of the seven ages in the human life cycle might be read. "As You Like It," Act II. Scene II, near the end, commencing, "All the world's a stage," etc.

[Reprinted from the JOURNAL OF APPLIED MICROSCOPY, Vol. I, No. 7.]

Some Apparatus to Facilitate the Work of the Histological and Embryological Laboratory.

Every teacher who has to direct the work of beginning classes and of thesis and research students, is compelled from time to time to make modifications of apparatus, or under special stress to construct wholly new pieces. Indeed, as has been well said, a laboratory teacher who is not also something of an inventor cannot attain the highest success. Attention is called to the following pieces of apparatus, hoping that they will serve to give hints to other teachers, and trusting that they, or some modification to meet special needs, will prove as serviceable to other laboratories as they have to my own. Most of them have been figured and described already in some form. The figures here given represent the latest and most satisfactory modifications.



Name of Article: Round Aquarium Jars (1 Liter capacity). Cost, $ 6.00. No. of Pieces: 24. From: Whitall Tatum & Co. Inventoried: 1898. Address: 46, 48 Barclay St. N.Y. Order No. 113. Date: June 15, 1898. Date of receipt of Articles: July 2, 1898. Remarks: Used for waste jars and for water. Dep't.: Histology. NEW YORK STATE VETERINARY COLLEGE, CORNELL UNIVERSITY.

Fig. 1. Inventory card.

To begin with, the laboratory teacher is in most cases held responsible for the property of the laboratory, and it falls

10 CENTIMETER RULE.

The upper edge is in millimeters, the lower in centimeters and half centimeters.

THE METRIC SYSTEM.

UNITS.	*The most commonly used divisions and multiples.*
THE METER FOR LENGTH . . .	*Centimeter* (c.m.), 1-100th Meter; *Millimeter* (m.m.), 1-1000th Meter; *Micron* (μ), 1-1000th Millimeter; the Micron is the unit in Micrometry. *Kilometer*, 1000 Meters; used in measuring roads and other long distances.
THE GRAM FOR WEIGHT . . .	*Milligram* (m.g.), 1-1000 gram. *Kilogram*, 1000 grams, used for ordinary masses, like groceries, etc.
THE LITER FOR CAPACITY . .	*Cubic Centimeter* (c.c.), 1-1000th Liter. This is more common than the correct form, Milliliter.

Divisions of the *Units* are indicated by the Latin prefixes: *deci*, 1-10th; *centi*, 1-100th; *milli*, 1-1000th.

Multiples are designated by the Greek prefixes: *deka*, 10 times; *hecto*, 100 times; *kilo*, 1000 times; *myria*, 10,000 times.

[This card (12⅜ 7⅛ c.m.) is the size used for library catalogs.]

Fig. 2. The metric system in a nut-shell.

to him to indicate what is necessary to carry on the work. To facilitate this labor, and to make easily accessible a knowledge of the cost, place of purchase or the time required to obtain any piece of apparatus or any material needed in the laboratory, the catalog blank (Fig. 1) has been evolved during the last 10 years. The card has been filled out in script from an actual case. In addition to the information given in this card, there is usually present a mark showing where the apparatus is to be found, thus adopting the principle of shelf marking used in libraries.

To facilitate the understanding of the metric system which is required in all our work each student is supplied with a card of the standard size used in library catalogs, shown in Fig. 2.

Fig. 3. Laboratory Table, adjustable stool, water and waste jars, and screen.

The most convenient size for a laboratory table is about 125 cm. long, 72 cm. wide, and 72 cm. high, (48 in. long, 28 in. wide and 28 or 29 in. high); and for a seat, an adjustable piano stool, costing from $1.50 to $2.00.

For the most critical microscopic work one most conveniently faces the light; this is hard on the eyes and hence some form of a screen is exceedingly useful. Those figured in Fig. 3, 4 were made by inserting a wire in a tin patty dish and filling the dish with lead. The wire is bent at right angles and a sheet of heavy paper high enough to screen the eyes and low enough to shade the stage, but not to interfere with the mirror is hung on the bent wire.

Many workers find no difficulty in keeping both eyes open, simply neglecting the images of the eye outside the ocular, but the majority find it hard to do this. Various eye shades have been devised to obviate the trouble.

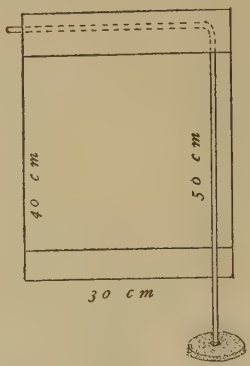


Fig. 4. Screen for shading the microscope and the face of the observer.

One which has the advantage that it may be used for either eye and thus encourages the use of the eyes alternately is shown in Fig. 5.

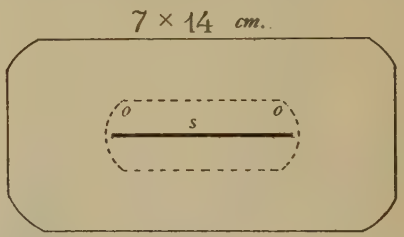


Fig. 5. Double Eye-Shade. This is readily made by taking some thick bristol board 7 x 14 centimeters and making an oblong opening with rounded ends (o——o) and of such a diameter that it goes readily over the tube of the microscope. This is then covered on both sides with velveteen and a central slit (s) made in the cloth. This admits the tube of the microscope and holds the screen in position. It may readily be pulled from side to side and thus serves for either eye, or for the use of the eyes alternately.

Twenty years experience has shown that in a laboratory there must either be a microscope for each student, which is the best plan—or some arrangement by which two or more can use one microscope and be held responsible for it. The form of cabinet finally adopted is shown in Fig. 6.

The outside doors put the entire equipment under the control of the teacher. The small lockers make it possible to give each microscope to a definite number of students, who can be held accountable for it.

In order that specimens may have a neat appearance and be uniform, it is a

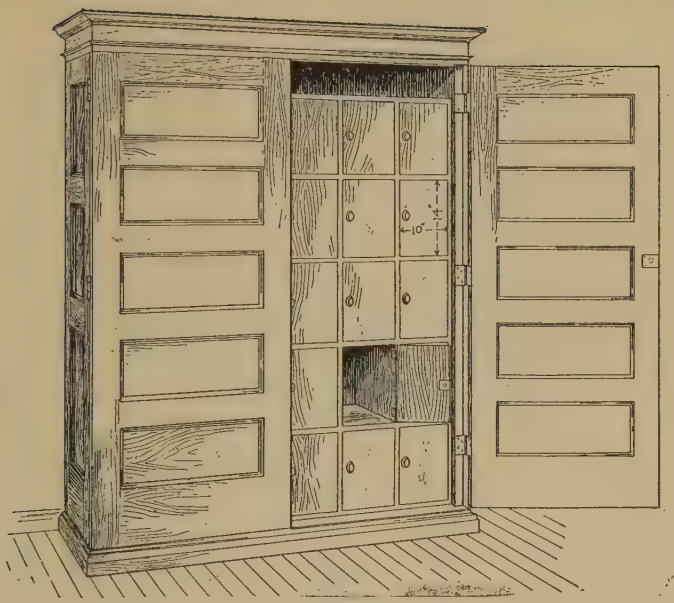


Fig. 6. Cabinet for Microscopes.

great help for beginners to have some kind of a guide in mounting. Fig. 7 shows such a device.

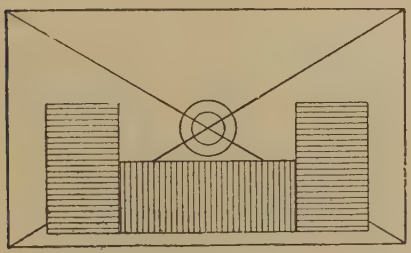


Fig. 7.

A convenient label is shown in Fig. 8. As illustrated in the filled out label the thickness both of the cover-glass and

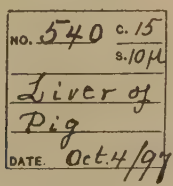


Fig. 8.

of the section is indicated. The thickness of the cover is in hundredths of a millimeter, that of the sections in microns (μ).

As it is desirable to have every student independent each should be given, if possible, an individual locker for his specimens and material. The lockers available in the histological laboratory at Cornell are shown in Fig. 9. For each there are several reagent boards with holes of various sizes and a drawer. Some of the reagent boards have holes about 25 mm. in diameter for the preparation vials shown in Fig. 12, and they also serve very well indeed for storing paraffin imbedded tissues.

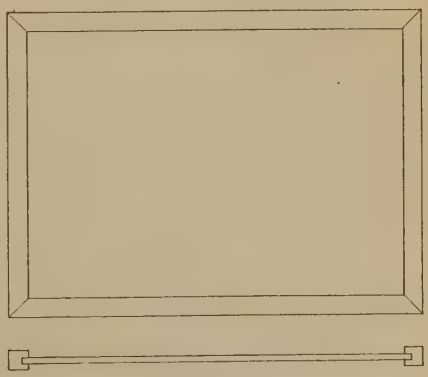


Fig. 10.

For paraffin ribbons and for temporary mounts or for working series the rather expensive slide drawers (Fig. 10 A) and

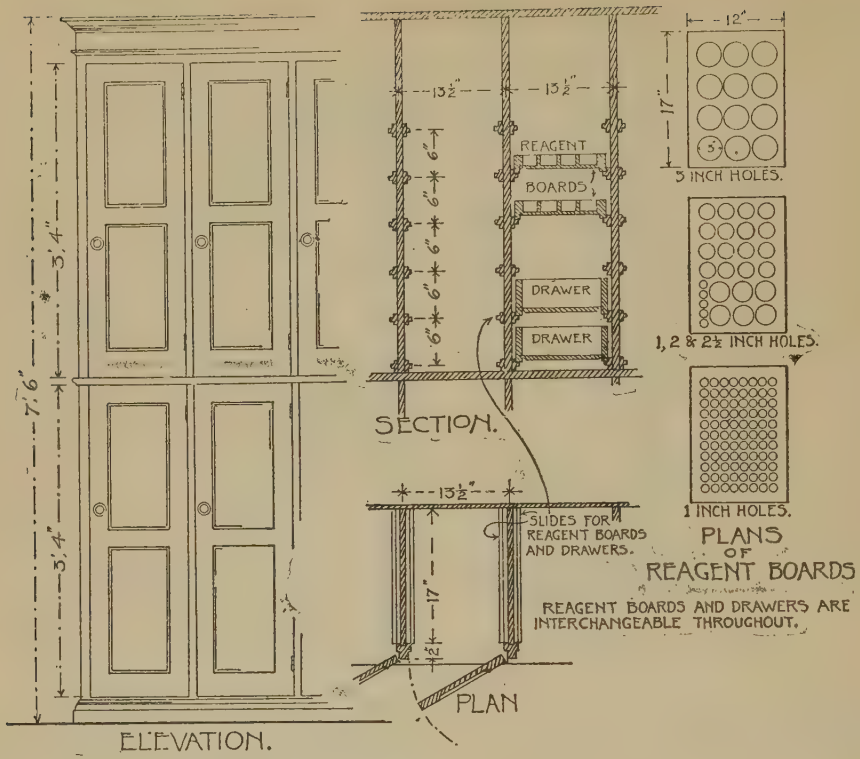


Fig. 9. Lockers and Reagent Boards.

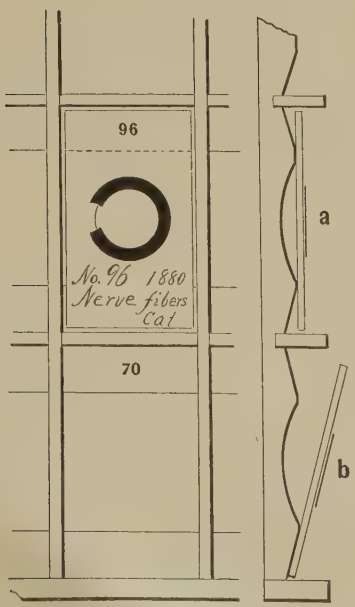


Fig. 10A.

Fig. 10 and 10 A. Face and sectional views of slide drawers.

cabinets are hardly available, and not altogether suitable. Instead, shallow drawers are used. One is shown in face and in sectional view in Fig. 10.

These fit the lockers and several of them may take the place of a reagent board or a drawer. As they have an edge all around, any one may easily be removed without disturbing the others. Each drawer is about 30x43 centimeters (12x17 in.) and holds 50 slides. They cost only about $12.00 per hundred and have proved a great convenience during the two years in which they have been in use.

There have already appeared descriptions of two markers in the Journal, showing how widely the need has been felt. Probably a dozen different methods have been devised for finding some part of a microscopic specimen. The marker here shown is simple and has proved of great help for marking specimens to be used in class demonstrations and in special study. This form of a finder has the advantage that a slide marked by it can be used on any microscope.

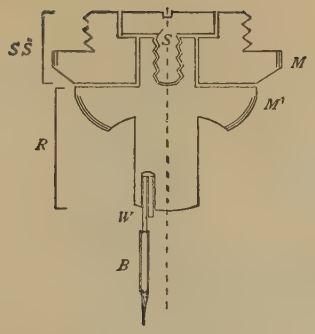
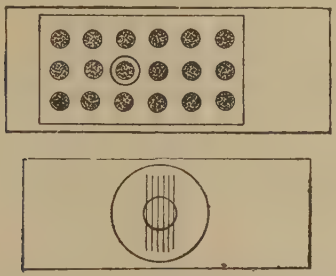


Fig. 11. The marker consists of the part SS with the milled edge (M). This part bears the Society or objective screw for attaching the marker to the microscope. R. Rotating part of the marker. This bears the eccentric brush (B) at its lower end. This brush is on a wire (W). This wire is eccentric, and may be made more or less so by bending the wire. The central dotted line coincides with the axis of the microscope. The revolving part is connected with the "Society Screw" by the small screw (S).



Section of a series marked to indicate that this section shows something especially well. The lines of a micrometer are ringed to facilitate finding the lines.

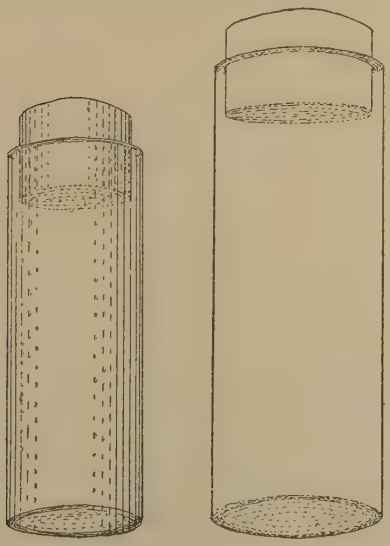


Fig. 12. Shell vials.

For much of the work of histology and embryology, small wide-mouth shell vials are very convenient. Three sizes have answered most purposes, 18x50 mm., 23x65mm., and 35x90 mm. The lips should be slightly flared. The cost is $2.00 per gross for the smaller ones and $6.00 per gross for the largest ones. These are not good for long storage. They are for preparing objects. For long storage nothing is so satisfactory as a glass stoppered bottle. The larger of these vials takes a slide and is very useful for staining, clearing, etc.

For reagents which are to be used with a dropper or pipette, bottles of various sizes are employed. That volatile liquids shall not evaporate, a cork is perforated and put over the glass tube as shown in the figure.

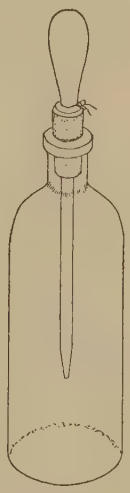


Fig. 13. Reagent bottle with combined cork and pipette.

For preparing objects a waste bowl or dish with a rack on the top for supporting the slides, a drainage funnel, etc., is very convenient. One may use an ordinary bowl or preferably an aquarium jar. (Fig. 3). The rack is made of two pieces of sheet lead into which are soldered brass rods. The funnel is made of brass or copper.

For balsam, and homogeneous oil, no receptacle has been satisfactory for daily use except a capped bottle like a small spirit lamp. Fig. 15.

A moist chamber for blood preparations, etc., can be very simply made with a bowl or an equarium jar and a white dinner plate.

Fig. 14. Waste bowl with rack and drainage funnel (see also Fig. 3).

Fig. 15. Capped holder for Balsam and homogeneous oil with glass rod.

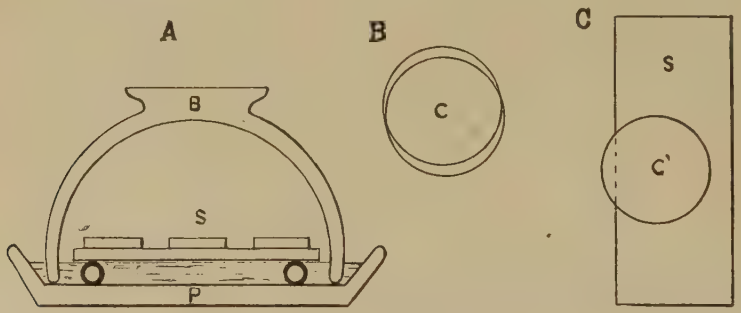


Fig. 16. Simple moist chamber.

In handling amphibian eggs and other small and delicate objects an egg pipette may be easily made by cutting off a short medicine dropper and adding to the tip some soft rubber tubing. It is easy with this to catch and handle young embryos of frogs, salamanders, etc.

Objects fixed with osmic acid alone or in combination with chromic acid or platinic chlorid (Flemming's or Hermann's solutions, etc.), require to be washed out a long time in running water. To accomplish this washing without danger to the tissue and still thoroughly, the following arrangement was devised: A small side tap was put in the pipe leading to the ordinary faucet. A copper box with a small tube near the bottom was put at one corner and this was connected with the washing tap by a rubber tube. A skeleton box with projecting edge was then made to fit inside

Fig. 17. Egg-pipette.

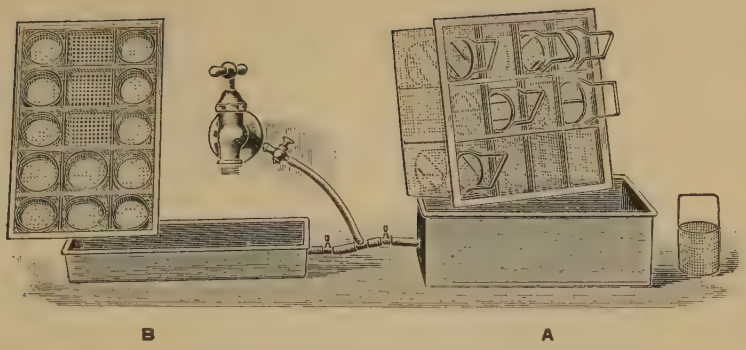


Fig. 18. Washing apparatus for tissues fixed in osmic acid, etc.

the receiver. This skeleton, inside box is divided up into a dozen compartments and for each a little basket is prepared. The tissue is put into the little baskets and they are placed in the compartments as shown in the figure (Fig. 18 A).

The outside box is about 1 centimeter deeper than the inside one and the water runs in at the bottom and out over the top. This insures a constant change of the water, and as the water enters at the bottom it must pass through the perforations of the inside box and of the little basket before coming in contact with the tissue; it can be seen that the current is very gentle when it reaches the tissue. This apparatus has now been in use about six months and has proved very satisfactory. The washing apparatus shown in B, will be described by one of my students in a later issue of the Journal.

For heating gelatin for injections and paraffin for filtering, etc., a combined receptacle and water bath was devised. The cut shows the construction.

For the filtered paraffin that is to be used for imbedding, a combined water bath and receptacle was devised in which the water bath nearly surrounded the paraffin receptacle as shown in the cut. For a large laboratory the paraffin receptacle should hold about one liter.

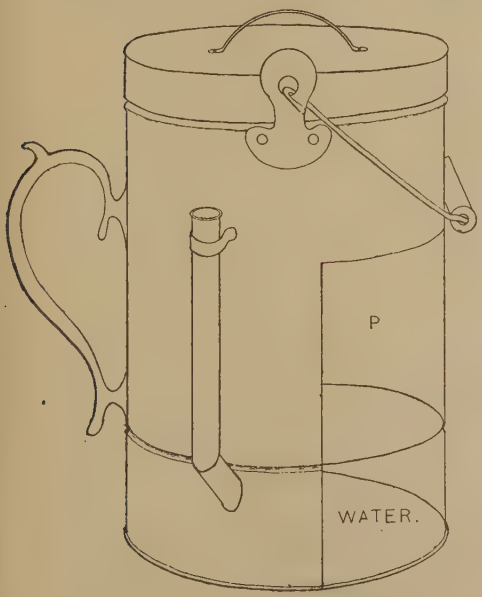


Fig. 19. Combined receptacle and water-bath for melting paraffin, and for gelatin injection masses.

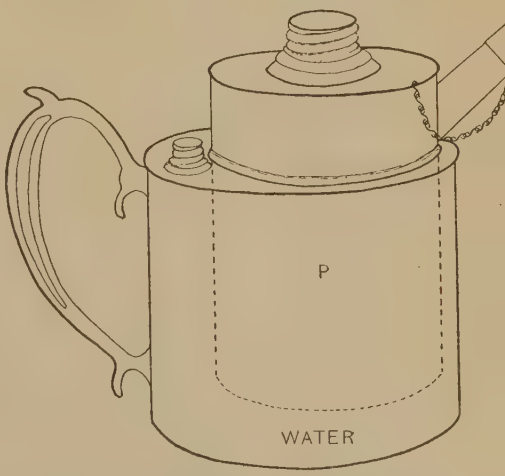


Fig. 20. Paraffin receptacle with water-bath, and spout for paraffin imbedding. P—Paraffin.

In filtering paraffin and gelatin some form of hot filter is necessary. The form here shown has worked admirably.

So much trouble was experienced in filtering from the clinging of the filter to the sides of the vessel that a wire basket leaving about 1 cm. space all around was devised. The filter paper or flannel is put in this and the paraffin or gelatin is then poured in as usual and as the filtered material oozes through the sides it runs down the wires to the outlet.

For collecting with a bicycle I have found a can with a very large screw top very convenient. It is water tight in any position, and can be easily put into almost any form of bicycle carrier. A leather bag attached to the handle bars has proved convenient. Many times one needs considerable space and a pair of two-liter cans have frequently been carried.

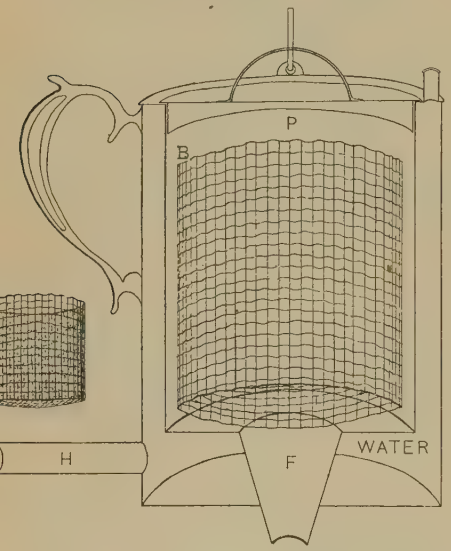


Fig. 21. Hot filter for paraffin and gelatin, in section. B. B. Wire basket somewhat smaller than the receptacle. The Flannel or filter paper is put inside this. H. Closed tube continuous with the water bath. The Bunsen burner or the alcohol lamp is put under this.

F. Outlet of the filter.

P. The receptacle for the paraffin, etc. The cover fits inside P. and the whole is suspended by a bail.

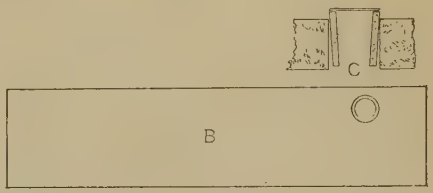


Fig. 23. Circulation-board for Necturi and frogs. It is composed of a board about 8 x 30 centimeters with a perforated cork bearing a thick cover inserted in a hole near one edge. B. The circulation board. It is covered with cloth or blotting paper. C. Sectional view showing the covered cork in place.

All the metal apparatus described in this article has been made of copper or brass, tin rusts out too soon. For the washing outfit (Fig. 18) wire netting may be used, but perforated copper or brass is more satisfactory, (Fig. 18 B).

SIMON HENRY GAGE.

Cornell University, July 18, 1898.

Fig. 22. Screw-top copper can for collecting with a bicycle.

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Assistant Professor of Veterinary Anatomy and Anatomical Methods.

ARTICLE.

Some Lungless Salamanders. Illustrated.
American Naturalist, Vol xxx, October, 1896. Pp. 829–833.

THE HEART OF SOME LUNGLESS SALAMANDERS.[1]

By G. S. Hopkins.

From the American Naturalist, October, 1896. Pp. 829-833.

The recent literature of zoology has, perhaps, contained nothing more unexpected and startling than that certain adult salamanders are entirely lacking in those respiratory organs, which, heretofore, have been deemed indispensable to the existence of animals so high in the zoological scale as the Amphibia. This total lack of lungs and branchiæ appears the more marvelous when we remember that they are absent in forms which lead a rather active and wholly terrestrial life, as well as in those of more or less purely aquatic habits.

Two questions are naturally suggested by this apparently aberrant condition of the respiratory organs. First, what structures or organs have taken on the functions of the lungs and branchiæ? and secondly, is there any modification in the form or structure of the heart which in any way may be correlated with the above mentioned peculiarities of these lungless forms?

The first of these two questions has been discussed to some extent by Prof. Harris H. Wilder, of Smith College, who first published an account of this apparently anomalous condition. He concluded that respiration was probably carried on by the skin and, perhaps, to some extent by the mucosa of the intestine. Prof. Camerano has also published the results of some experiments upon two European forms which bear upon this same question. He believes that in these lungless forms respiration is effected in the bucco-pharyngeal cavity, and that the skin affords no efficient aid in the respiratory processes.

In a still later paper he discusses the subject further, and tries to account for the disappearance of the lungs. Of one aquatic species (of the genus Molge) he says: "The function of the lungs as hydrostatic organs, is very marked." "In the clearly terrestrial forms one would say that the diminution in importance of the function of the lungs as hydrostatic organs induces a retrogressive development of them while at the same time the importance of the bucco-pharyngeal respiration is increased."

It appears to the writer that Camerano's conclusions need to be tested by further experiments, especially the part referring to the res-

[1] Read before the Amer. Assoc. Adv. Science, Aug. 24, 1896.

piration, for the area of the dermal surface far exceeds that of the bucco-pharyngeal cavity, and the skin is also very richly supplied with blood vessels which are so close to the surface that it would appear as if the gases of the blood and air might be readily interchanged. It is hoped that time will permit of some experiments on this point during the coming year.

As to the second question, whether there is any appreciable modification of the heart in these lungless salamanders, nothing whatever has been published.

It is the object of this paper to call attention to the fact that there is a difference in the heart of those salamanders that do not have lungs and those which do have them. So far as I have examined, it is possible to distinguish between the two forms by examining the heart alone.

In order that what is said on this point may be clearly understood by every one, and in order to bring out the differences between the two more sharply, if possible, I wish first to recall to mind the structure of the Amphibian heart and then contrast with it the relations as found in the heart of a lungless individual. We may take Huxley's description of the Amphibian heart as our standard of comparison. In his Anatomy of Vertebrates he says: "The heart presents two auricles, a single ventricle and a bulbus arteriosus. A venous sinus, the walls of which are rhythmically contractile, receives the venous blood from the body and opens into the right auricle. The left auricle is much smaller than the right and a single pulmonary vein opens into it." In regard to the septum of the auricles, he says that "it is less complete in Proteus, Siren and Menobranchus (Necturus) than in other Amphibia. In Menobranchus the septum is reduced to little more than a wide meshed network of branched muscular bands, and in Proteus the existence of a septum is doubtful."

The heart of our common Newt (Diemyctylus viridescens) Fig. 1 or of the large yellow-spotted salamander (Amblystoma punctatum), for examples, corresponds perfectly with Huxley's description. In both of these forms the auricular septum is perfectly complete, the cavities of the auricles being entirely separated, except just at the auriculo-ventricular aperature, at which point the two auricles communicate with each other to some extent.

In Necturus, the septum is more or less fenestrated and, according to Huxley, it is very incomplete in Proteus and Siren, but in all of the forms that have been mentioned, as well as in other members of the class Batrachia, the sinus venosus opens distinctly into the right auricle and the pulmonary vein into the left.

Let us now compare the heart of a lungless salamander (Fig. 2.) with the one just described. The four parts, auricles, ventricle, bulbus arteriosus and sinus venosus are clearly recognizable and, superficially examined present nothing unusual; it is only when the cavities are

opened that the differences between the two hearts become apparent. One of the first things to attract attention is the left auricle. In the lungless forms examined, it is much smaller in comparison to the right than in Diemyctylus, for example, and *no pulmonary vein was found opening into it.*

The auricular septum has only one opening through it, or perhaps, more correctly, it extends only part way across the cavity, but this aperature in the septum is so large (Fig. 2, 9.) that it is believed the communication between the two cavities is more free than even in Necturus. Just what function or functions the septum may have in these lungless forms, it seems to me, is not quite clear. That it has but little, if any use, is indicated by the way the sinus venosus opens into the auricles. In place of opening into the right auricle only, as in the forms having lungs, *it opens more freely into the left auricle than into the right.* If the ventral parietes of the heart be removed, one can look directly into the opening of the sinus venosus from either of the auricles, but more directly into it from the left than from the right, for when seen from the latter, one must look through the large opening of the auricular septum, Fig. 2, 9. In salamanders with lungs, each auricle opens in common into the ventricle with about equal freedom of communication, whereas in the lungless forms the right auricle is in more direct communication with the ventrical than is the left.

Judging from the above facts, i. e., the way the sinus venosus opens into the auricles, the freedom with which the auricles communicate with each other, and the way the auricles communicate with the ventricle, it would seem as if the heart of the lungless salamanders, functionally, was only bilocular in place of being trilocular as in the rest of the Amphibia. Morphologically, of course, it is trilocular, but whether it is so physiologically, seems to me doubtful.

The hearts of 8 lungless species have been examined by the writer, and so far as was made out, all of them agree closely with the description as given above. The probabilities are that in all the lungless forms similar conditions of the heart will be found. Up to the present time 17 species and sub-species, either wholly without lungs or with only functionless rudiments of them, have been reported. In his last paper, in which are enumerated 15 of the 17 lungless species, Wilder says that "in the Salamadridæ lungless species are as numerous as those possessing lungs, and that in consequence of this, the definition of the group must be modified." It seems, however, that even with his proposed additions, the definition is still not sufficienty comprehensive, for the peculiarities in the structure of the heart certainly have almost as profound a significance as the absence of the lungs themselves, and should be incorporated in any definition that may be given. In addition to the 17 lungless species already mentioned, the writer has found an additional one, *Spelerpes gluttolineatus.*

PLATE XVI.

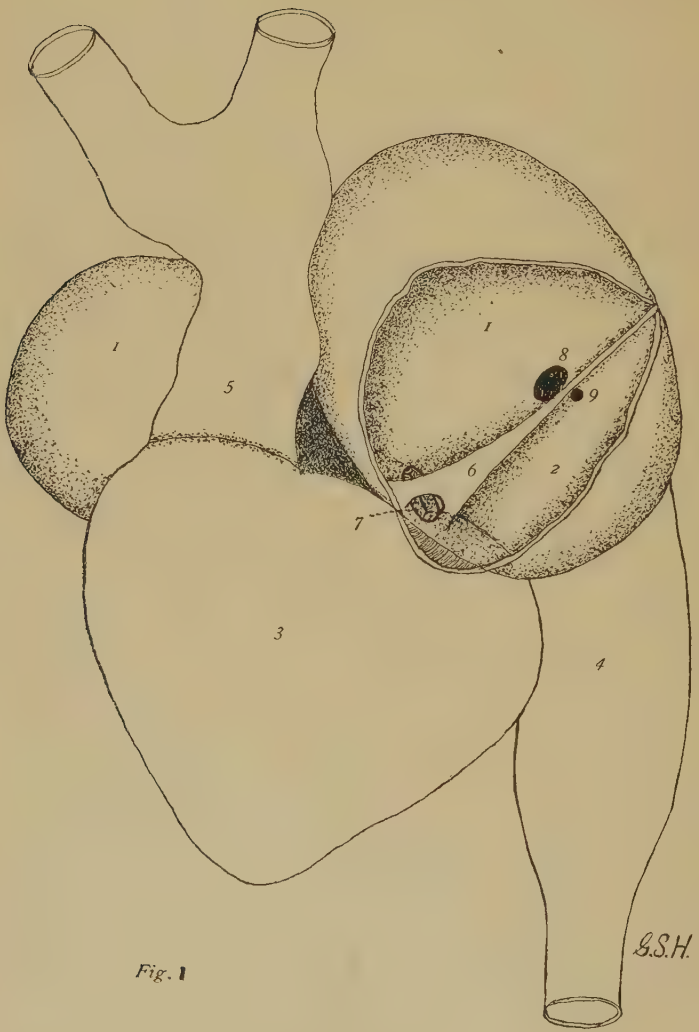

Fig. 1

Hopkins on Diemyctylus.

PLATE XVII.

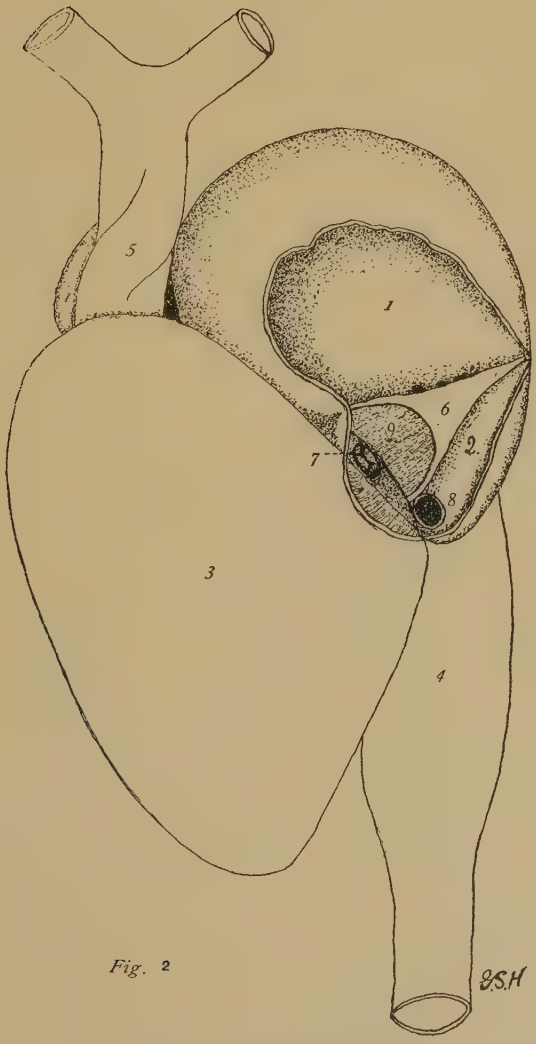

Fig. 2

Hopkins on Desmognathus.

In order that one may see at a glance in which families and genera lungless individuals are found, the following table, taken from Prof. Cope's Batrachia of North America, is appended. [The last column is taken from the papers of Wilder and others.]

Families.	Genera.	No. of species.		No. of species without lungs or with only rudiments of them.
Cryptobranchidae	Cryptobranchus	2		
	Megalobatrachus	1		
Amblystomidae	Amblystoma	12	[N.A.]	1 A. opacum
		1	[Siam]	
	Chondrotus	7		
	Linguaelapsus	2		
	Dicamptodon	1		
Hynobiidae [all Asiatic]	Hynobius	5		
	Salamandrella	2		
	Onychodactylus	1		
	Ranidens	3		
	Batrachyperus	1		
Plethodontidae	Plethodon	8		2 P. cinerus, P. erythronotus, P. glutinosus
	Hemidactylium	1		
	Batrachoseps	4		1 B. attenuatus
	Stereochilus	1		
	Autodax	3	[European]	1 A. lugubris
	Geotriton	?		1 G. fuscus
	Gyrinophilus	1		1 G. porphyriticus
	Manculus	2		1 M. quadridigitatus
	Spelerpes	9		3 S. bilineatus, S. ruber, S. gluttolineatus
	Oedipina			
	Oedipus	9		
Thoriidae	Thorius	1		1 O. variegatus
Desmognathidae	Desmognathus	3		1 D. fusca, D. f. brimleyorum, D. f. auriculatus
Salamandridae [Old World]	Chioglossa	1		
	Salamandra	3		
	Hemisalamandra	1		
	Triturus	6		
	Pachytriton	1		

Families.	Genera.	No. of species		No. of species without lungs or with only rudiments of them.
Pleurodelidae [All found in Old World; three species in N. A.]	Salamandrina	1	[2N. A. species]	1 S. perspicillata
	Diemyctylus	10		
	Pleurodeles	1		
	Glossolega	3		
Amphiumidae	Amphiuma	1		
Coeciliidae	(numerous)		(numerous)	

In the last column of the above table, the figures indicate the number of species in which lungless individuals have been found. Where there is a discrepancy in the numerals and the number of species following them, it indicates either sub-species or species not mentioned in Cope's Batrachia of North America.

Description of Figures.

Fig. 1. Heart of Diemyctylus viridescens (semi-diagramatic) to show the general relations of the heart of a salamander with lungs. The ventral wall of the heart has been removed in order to show the auricular septum, the openings of the sinus venosus and the pulmonary vein, and also the relation of the auriculo-ventricular aperture to the right and left auricle.

1. Right auricle; 2. left auricle; 3. Ventricle; 4. Sinus venosus; 5. Bulbus arteriosus; 6. Auricular septum; 7. Auriculo-ventricular aperture; 8. Aperture of sinus venosus; 9. Pulmonary vein.

Fig. 2. Heart of Desmognathus fusca (semi-diagramatic) to show relations of the heart in a lungless salamander. The ventral wall of the heart has been removed.

1. Right auricle; 2. left auricle; 3. Ventricle; 4. Sinus venosus; 5. Bulbus arteriosus; 6. Auricular septum; 7. Auriculo-ventricular aperture; 8. Aperture of sinus venosus; 9. Opening through auricular septum.

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ARTICLES.

The Structure and Morphology of the Oblongata in Fishes.
The Journal of Comparative Neurology. Vol vii, No. 1.
April, 1897. Pp. 1-36.

The Encephalic Evaginations in Ganoids.
The Journal of Comparative Neurology. Vol. vii, No. 1.
April, 1897. Pp. 37-44.

The Demonstration of Karyokinesis,
Journal of Applied Microscopy. Vol. 1, No. 5.
May, 1898. Pp. 80-83.

THE STRUCTURE AND MORPHOLOGY OF THE OBLONGATA IN FISHES.

By B. F. Kingsbury.

With Plates I-V.

The writer was engaged in the study of the Amphibian brain at the time of the appearance of the monograph by O. S. Strong on the cranial nerves of Amphibia. Especially was it then attempted to determine in *Necturus* the ental origin of the nerves of the oblongata, and many results attained by Strong had been independently gained by me, largely under the stimulus of his preliminary papers, but the broad view and general application which made Strong's paper so valuable a contribution were in a degree wanting in my own.

In Strong's comparison of the cranial nerves of Amphibia with those of "fishes" in the effort to find in the latter the representatives of the components already recognized by him, it was difficult to harmonize the accounts by various writers of the origin of certain of the nerves in the different forms. When, therefore, opportunity was afforded me during the past year of studying the brains of several ganoids and teleosts, especially *Amia* and *Amiurus*, one of the objects was to confirm the homologies suggested by Strong, to find in these forms the representatives of the nerve components previously recognized in Amphibia, and to identify in these so variously modified brains the corresponding regions, and determine their morphologic and structural relations.

It is the ultimate purpose, as just suggested, to work out somewhat carefully by means of the Weigert and Golgi methods the structure and relations of the regions of this part of the brain for certain ganoids and teleosts, in order to gain a more exact knowledge of the connections of the various nidi with each other and with the rest of the brain and myel. This

last task is far from complete; however, pending the time when results in this difficult field may be gained of sufficient definiteness and coherence to render their publication of value, a more general consideration of the dorsal portions of the oblongata in fishes may serve to emphasize the regions whose various modifications have produced the truly enormous structures of certain teleosts, namely;—(1) the center of the acoustic and lateral line system nerves; (2) that portion which is the undoubted representative of the *fasciculus communis* portion of the Amphibian oblongata; and (3) the spinal fifth tract, the direct continuation of the dorsal columns of the myel. These are three *systems* having constant relations to certain cranial nerves, and should have names indicative of their character. It seems unwise, however, to introduce new terms. They will be spoken of as the (*Systema*) *acusticum*, the *fasciculus communis* or (*fasciculus*) *communis* system and the spinal Vth (fifth) tract, respectively.

The forms considered here[1] comprise 17 species, representing among the teleosts 10 families and 5 orders. Although far too few to permit any general conclusions being safely drawn as to the characteristic development in the various orders or even families, they yet strongly suggest what may be the case, and have given a far better idea of the extent and significance of the modifications of the regions.

This study was conducted by means of serial sections made through this region of the brain. Where but a single series was made the sections were transverse; in some cases supplementary series were made in the other two planes. The brains were fixed in Fish's picro-aceto-sublimate (formula: picric acid, 1 gram; mercuric chloride, 5 grams; glacial acetic acid, 10 c.c.; 50% alcohol, 1000 c.c.) or vom Rath's picric-sublimate-acetic mixture (formula: picric acid, sat. aq. sol. 100 c.c., hot sat. sol. mercuric chloride 100 c.c., glacial acetic acid 2 c.c.)

[1] Namely, *Amia calva*, *Lepidosteus osseus*, *Acipenser rubicundus*, *Amiurus nebulosus*, *Catostomus teres*, *Notemigonus chrysoleucus*, *Exoglossum maxillilingua*, *Notropis cornutus*, *Cyprinus carpio*, *Clupea pseudoharengea*, *Esox reticulatus*, *Cottus ictalops*, *Perca flavescens*, *Lepomis gibbosus*, *Roccus chrysops*, *Fundulus diaphanus*.

Of these two the aqueous formula seemed more satisfactory, although they were not tested for comparative results. With these the stains employed were Delafield's hematoxylin and Van Gieson's picro-fuchsin. The hematoxylin and picro-fuchsin were preferably used separately and all staining was in section. The hematoxylin was used much dilute and allowed to act some time and overstain slightly; subsequent staining in the picro-fuchsin lasted until all the hematoxylin was removed from the collodion in which all the brains were embedded and cut. An alcoholic (67 %) picro-fuchsin stain was also employed. Weigert staining was conducted in the usual manner and these brains were fixed and hardened in 3 and 5% solutions of potassium dichromate several weeks.

The work was conducted in the Anatomical laboratory of Cornell University, and to the Anatomical Department I am indebted for much material and all the facilities of research. Professors Wilder and Gage have helped me with their kindly interest, suggestions and advice, and the latter has lent me personal assistance in procuring material; for all of which I would express my grateful appreciation. All the *Acipenser* material was obtained and fixed by Dr. O. D. Humphrey of Erie, Pa., and to his care and skill the results obtained were due.

Of the forms studied, the Ganoids, and Amia in particular, form from every point of view the more natural and convenient basis for comparison and point of departure in studying the oblongata of bony fishes. Because of the presence of a cerebellum of typical structure, and the even development of the parts of the oblongata, *Amia* presents advantages over the simpler urodelan brain on the one hand and the other ganoids (as far as studied) and the teleosts on the other, which present greater though different complexities. Therefore it will be advantageous to discuss somewhat the oblongata and cranial nerves of *Amia;* avoiding, however, all details not necessary in connection with the purpose of this paper.

The transition from myel to oblongata in *Amia* is gradual enough, and the cornua of the cinerea well enough defined (as contrasted with the simpler *Necturus*) to permit the following of

myelic structures into the oblongata, and it is in the dorsal portions, as usual, that the change is most marked. In a section of typical myel the ventral cornua are narrow and extend latero-ventrad; dorsad of the myelocoele is a region of cinerea from which the delicate dorsal cornua extend terminating in swellings composed of amyelinic fibers and "ground substance" with numerous small cells interspersed. Surrounding these on the dorsal, mesal and lateral sides are fine closely aggregated myelinic fibers. The ventral tracts are composed of coarser fibers with the characteristic Mauthner fibers; the lateral tracts are formed of fibers, in general, intermediate in caliber between those of the dorsal and ventral portions.

As the oblongata is approached, the dorsal horns enlarge, gaining a size three or four times that characteristic of the myelic portion (Figs. 6 and 13). At the same time the typically small myelocele enlarges and assumes a subtriangular section; the sulci forming the angle sextending toward the dorsi-meson and the ventral cornua. The larger part of the dorsal fibers disappear and just caudad of the metatela a concentration of fine fibers on the dorso- and ventro-lateral sides of the cornua mark the first recognizable appearance of the spinal Vth tract. At this level the dorsal cornu and the gelatinosa rapidly disappear. (Fig. 15).

Near the caudal end of the metatela, a lateral sulcus appears, and dorsad of it the first appearance, as such, of the fasciculus communis (lobus vagi). (Fig. 15).

Increase in size of the fasciculus communis tract and migration ventrad of the spinal Vth tract give the former for a short distance a dorsal position. Soon, however, there appears dorsad of the spinal Vth tract and the fasciculus communis an area of fibers and intermingled small cells, which increases rapidly in extent and soon becomes capped by a layer of amyelinic substance, the cerebellar crest (cerebellarleiste of Goronowitsch), a caudal continuation of the molecular layer of the cerebellum (Figs. 16, 17). The change in the morphology of the oblongata from this point cephalad is simply in the increase in size of this, the acusticum, displacing farther ventrad the spinal Vth

tract, and the revolution of the wall between the ventral and lateral sulci somewhat from a vertical to a more horizontal position (Figs. 16-18).

Nerves. The vagus nerve arises by 4 (or 5) large roots each made up of two or three smaller rootlets. The most caudal root is undoubtedly purely motor and may be recognized some distance caudad of the metatela as an ascending tract.[1] As it passes cephalad it is reinforced several times by fibers from the the ventral horn, especially at its exit where a number of fibers come from the motor vagal nidus (Zwischenzellen of Goronowitsch) now recognized as a distinct cluster of cells. (Fig. 15, ni). The roots cephalad contain both motor and sensory (ganglionated) fibers and all arise in much the same way, the sensory from the fasciculus communis system (lobus vagi) as shown in Fig. 16, the motor from the vagal motor nidus and apparently also from cells of the ventral cornu proper, though they may yet arise from cells of the vagal nidus, the neurite simply bending ventrad first, it having in no case been traced into any cell. The caudal rootlets go ventrad of the spinal Vth tract, the cephalic ones dorsad of it (Fig. 16), while the intermediate roots break through it in passing to their exit. It was difficult to determine definitely whether the vagal roots which penetrated the spinal Vth tract drew fibers from it or not. However, those which passed dorsad to it clearly received a small contingent of fine fibers from it. This is important. Strong, from the fact that in Amphibia vagal fibers were closely associated with the spinal (ascending) Vth, considered it probable that the same source for a portion of the fibers of the Xth existed in other Ichthyopsida. It will be seen later that a similar derivation of a portion of the fibers of the Xth occurs in at least some teleosts.

Accompanying the vagus is the lateral line nerve which after the former enters the brain continues cephalad some distance and is joined by the IXth which reaches it after piercing

[1]In this respect there is a close resemblance between *Amia* and *Necturus* (Amphibia).

the ear-capsule. The lateral line nerve is composed of the characteristic fibers with dense sheaths. It also receives a small contingent of fine fibers from the IXth and in turn gives to it a small bundle of its coarse fibers.[1] The IXth enters the brain first (Fig. 17) and sends a bundle to the fasciculus communis and one to the lateral nidus of cells, a continuation of the vagal motor nidus. The lateral line nerve soon enters the dorsal tract, the acusticum, just ventrad of the cerebellar crest and the fibers can be traced cephalad for some distance; whether any of them enter the cerebellum or not as Goronowitsch found in *Acipenser* has not been satisfactorily determined; it seems improbable.

Ascending fibers of the VIIIth nerve may be recognized at the level of the IXth, dorsad of the spinal Vth. This nerve leaves the oblongata just dorsad of the spinal Vth tract. Other fibers of the VIIIth seem to terminate immediately on entering the brain near the characteristic large laterally situated cells, so regularly found, and a few turn cephalad; however, the relations in this complicated region have not been made out at all satifactorily as yet. So far, *Amia* agrees quite closely with *Acipenser*, but in the origin of the remaining roots near the VIIIth there is a considerable difference. In the first place there does not exist in *Amia* the dorsal prominence present in *Acipenser* which was termed by Goronowitsch "lobus trigemini," and the nerve root issuing therefrom (*Trig. II dors.* of Goronowitsch) is absent as such. Very close to the VIIIth, so close as to be indistinguishable from it macroscopically, there arise in dorso-cephalic succession, VIIb and VIIaa;[2] the former of coarse

[1] Allis described the innervation of a dorsal line of free neuromasts and a canal organ by fibers of the IXth nerve. Undoubtedly the fibers received from the lateral line nerve have this distribution. It is precisely what we should expect.

[2] The names by which the roots were designated by Strong in Amphibia are here used to indicate the homologous roots in fishes. The reference of VIIb and VIIaa to the VIIth nerve are matters of convenience merely; VIIaa, seems, however, the undoubted homologue of the "pars intermedia Weisbergii."

The designation of the other cranial nerves by numerals is adhered to as better facilitating reference. It is insignificant otherwise.

fibers identical in appearance with those of the lateral line nerve and entering the acusticum, and the latter from the fasciculus communis system which disappears with the exit of this root. (Fig. 18). Cephalad of the VIIIth is the motor VIIth (VIIab) which has the typical mode of ental origin so constant in vertebrates and so well described in *Acipenser* by Goronowitsch. In addition to these there arises, sometimes ventro-cephalad of the VIIIth, sometimes dorsad,—there being a variation in this respect apparently,—a root composed of fibers from the spinal Vth. When it arises ventrally the fibers are drawn directly from the spinal Vth tract; when farther dorsad the fibers which form it have a course upon the ectal surface of the acusticum, from which the bundle may be easily distingushed, and may be traced caudad as a distinct strand as far as the cephalic rootlets of the Xth where it joins the spinal Vth proper. To which nerves (rami) these fibers eventually go has not been determined.

Some distance cephalad the remainder of the spinal Vth leaves the brain in connection with two rootlets from the trigeminal motor nidus to constitute the Vth nerve proper. A mesencephalic component was not recognized although the characteristic cells of the roof were found, and doubtless a root exists although I have not been able to determine its presence. So much as has been said of the cranial nerves in *Amia*, while not sufficient for a consideration of the nerves themselves will permit the recognition of the components recognized by Strong, and may serve to introduce a discussion of the corresponding regions of the oblongata, namely, as before mentioned, the spinal Vth tract, the fasciculus communis system, and the acustic system, the acusticum. A more minute discussion of the origin of the nerves and the structure of the oblongata is reserved.

Spinal Vth tract. The existence of the spinal (ascending) root for the trigeminal nerve has been quite generally recognized throughout the vertebrate branch and needs no comment here. Among Ganoids in *Acipenser* only had the presence of "ascending" trigeminal fibers been recognized, by Gorono-

witsch, though they were not followed caudad any distance. The view also that this tract represents the dorsal column in the myel and that its fibers correspond to the sensory fibers of spinal nerves needs not be emphasized. In fishes, teleosts especially, the correctness of this view seems quite evident and has been recognized by Mayser. In higher vertebrates we find this view supported by Kölliker, Gaskell and Turner; the latter considers the spinal root of the fifth and the solitary tract homodynamous, and apparently considers that both together represent the dorsal columns; Minot regards the *tractus solitarius* as continuing in the oblongata the dorsal column of the myel (*fasciculus ovalis* of the embryo). It is impossible therefore to draw any entirely satisfactory conclusions as to the representative of the dorsal column in the oblongata, since facts of development in all but mammals are wanting. The homology of the vagal component derived from this system in some lower forms, and of the *tractus solitarius*, is involved. Strong considers the fasciculus communis as the homologue of the tractus solitarius. Minot states that the late development of the spinal Vth tract in man interferes with a true comprehension of its value.

In *Amia* (and in certain teleosts at least) not only does this system furnish fibers for the Vth, but also for the Xth, as Strong assumed would be the case. The exit in *Amia* of a small portion of the fibers with the VII-VIII appears to be an exceptional condition, though constant in the few brains examined for it. An important point in regard to this tract in *Amia* (and other Ganoids) is that it is superficial. The enlargement of the dorsal horns caudad of the metatela produces corresponding ectal swellings resembling the clavas of the mammalian brain, and from these in specimens in which all connective tissue has been removed from the surface of the oblongata, the spinal Vth can be traced. A slight swelling caused by the tract and a difference in color from the surrounding portions, due apparently to the concentration of the fibers, renders it easily distinguishable with the unaided eye. It seems especially prominent in formalin preparations, and can be followed

readily into the Vth nerve (Fig. 3). Likewise in *Lepidosteus* the same tract may be macroscopically recognized.

Fasciculus communis system. It afforded considerable pleasure to recognize how exactly homologous the *lobus vagi* of Ganoids[1] is with the *fasciculus communis* of the Amphibian brain, thus confirming the homology proposed by Strong. In Teleosts, however, the homology should also be extended to the lobus trigemini, when that structure exists. In certain Teleosts (Nematognathi and Eventognathi as far as examined) the portion of the fasciculus communis system associated with the preauditory root (VII aa) is considerably developed and even (Eventognathi) fuses with its fellow across the meson (*Tuberculum impar*). This it is which was termed by Mayser *lobus trigemini.* The following table sets forth homologies the correctness of which will better appear later.

	Postauditory	*Preauditory*
Amphibia.	Fasciculus communis	Fasciculus communis
Ganoids.	Lobus vagi	Lobus vagi
Elasmobranchs	Lobi vagi	Lobi vagi (?)
Teleosts (some)	Lobus vagi	Lobus trigemini

The name *fasciculus communis* first given by Osborn to this structure of the Amphibian brain has been adopted by Strong, Burckhardt and the writer, for Amphibia and more generally applied (in *Amia*) by Allis, and seems to have become firmly established. It is unfortunate that the study proceeded from the Amphibia to fishes instead of in the reverse direction, since when the term fasciculus is applied to other Ichthyopsida it becomes somewhat inappropriate. Therefore some hesitation was felt in employing the name here. It should be remembered that it is not a fasciculus but a system or region of the oblongata. In those teleosts in which there is a distinction between

[1] The old term Ganoids is employed as a matter of convenience merely and is not intended as a prejudgement of the question of recognizing them as a distinct group. There are however some differences in the nervous system in Ganoids and Teleosts which I believe will prove to be constant.

the pre- and the post-auditory portions of this system the old terms *lobus trigemini* and *lobus vagi* are retained, the fact being recognized, of course, that the nerve root from the former belongs rather (on the present nomenclature) to the VIIth than to the Vth nerve. The "*lobus trigemini*" of Elasmobranchs and sturgeons will be referred to later.

Even in its highest development in Amphibia the *fasciculus communis* is much simpler than in Ganoids and appears simply as a highway in which fibers of a constant and peculiar appearance turn caudad from the VII, IX and Xth nerves; and the cells of the adjacent cinerea sending processes into the tract must be considered with it as the end nidus. The so-called *lobus vagi* of Ganoids includes nerve cells and thus must be more than the fasciculus communis of Amphibia. This tract in *Amia* resembles closely that in *Acipenser* and the description of Goronowitsch applies to *Amia* as well. The tract first appears near the caudal end of the metatela, just beneath the endyma. It increases rapidly in size and soon produces a marked swelling in the wall of the oblongata, occupying the most dorsal region, from which it is soon displaced by the development of the *acusticum* (dorso-lateral tracts) (Figs. 15–17). From it arise by far the greater part of the sensory fibers of the Xth and IXth nerves and a large root of the VIIth with the exit of which it disappears. In structure it consists of fine fibers with areas of ground substance and interspersed small cells, which also form a layer just beneath the endyma. The general resemblance between this structure in Ganoids and in Elasmobranchs is quite close.

The Acusticum. The most dorsal portion of the oblongata in *Amia* is occupied by the "dorso-lateral" tracts, which constitute the centre for the acustic and nerves of the lateral line system, and is here spoken of as the acusticum. It has certain constant connections with the rest of the brain and is capped by a caudal extension of the molecular layer of the cerebellum (cerebellar crest) as already stated. This intimate association of cerebellar structure with this portion of the metencephal is very striking and suggestive. Roughly speaking, in mammals

and birds the cerebellum consists of a cortex of well defined and characteristic structure and an ental mass of fibers. In reptiles the last seems to be wanting or ill-defined and the granular layer of the cinerea (cortex) becomes more closely applied to the endyma. Among the Ichthyopsida the simplest condition of the cerebellum exists in Urodeles, *Petromyzon* (Marsipobranchs?) and *Protopterus* (Dipnoans?) where it is represented by a bridge over the cavity cephalad of the metatela, composed of fibers passing from one side to the other, and an associated and sometimes insignificant layer of apparently indifferent nerve cells. In presumably all the remaining classes, at least in Ganoids, Teleosts and Elasmobranchs (*Rohon* '77, *Viault* '76, *Sanders* '86) the cerebellum presents the structure typical of the cerebellar cortex in higher forms, namely, an ental granular mass or layer and an ectal molecular layer of fine fibers, and between them a more or less well defined zone of large cells sending their dendrites into the molecular layer,—undoubted Purkinje cells. In all these (as far as examined) the molecular layer extends caudad over the oblongata, and *in Ganoids and Teleosts so far as investigated, it is associated only with the portion serving as the center for the acustic and lateral line system of nerves,* the *Acusticum.* This is an important relation that should be emphasized. In some forms at least, (e.g. *Amiurus* et. al. Fig. 11.) the layer of Purkinje cells also extends caudad upon the oblongata. In sharks and rays the molecular layer extends almost to the caudal limit of the metatela covering in part the so-called Lobi trigemini[1] and the *corpora restiformia* which also possess the granular and Purkinje cell layers.

Ascertainment of its exact relations in the oblongata of

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[1] "Im innigen Zusammenhange mit den *Lobi trigemini* stehen auch die *Corpora restiformia* welche gleichfalls nur eine directe Fortsetzung der oberen durcheinander gewundenen Hinterhirnsubstanz vorstellen. Anfangs bestehen die Corpora restiformia aus der Grundsubstanz oder Neuroglia [molecular layer] und den Antheilen der inneren Hinterhirnmassen, später aber bleibt von ihnen nur die Neuroglia zurück, welche sich als ein Mantel auf den oberen Seitenmassen des Nachhirnes, die Pedunculi cerebelli bedeckend, bis in die Hinterstränge des Rückenmarks erstreckt, wo sie die Substantia gelatinosa Rolando zum grössten Theile darstellt." Rohon, p. 84.

Elasmobranchs may render easier a close homologization of the regions there. So impressed was Goronowitsch with this relation of the molecular layer of the cerebellum in *Acipenser* that he regarded it as an indication of the primitive integrity of cerebellar and oblongatal regions.[1] Whatever may have been the primitive morphologic relations of the cerebellum to the oblongata, the point that should be emphasized, it is felt, is rather the present physiologic relation which must exist between the cerebellum and that,—morphologically most dorsal—part of the oblongata serving as the centre for the nerves of the ear and lateral line organs. Schaper has found that in teleosts as in mammals the fibers of the molecular layer arise by a forking, T-shaped origin of the neurites of the cells of the granular layer. In *Amia* and many if not all teleosts a large part at least of the fibers of the cerebellar crests of the two sides decussate in the caudal wall of the cerebellum, most clearly seen in *Amiurus*. This and other evident connections may better be discussed subsequently.

At this point very brief mention may be most conveniently made of *Lepidosteus* and *Acipenser*. A single specimen of the former was available. The resemblance between the oblongata of *Amia* and *Lepidosteus* is very close. As in the former, there is no trace of the so-called *lobus trigemini* of *Acipenser* nor any root to correspond to *Trig. II dors.* of Goronowitsch. The nerves present in *Amia* and their components were easily recognized, except that, since no Weigert preparations could be made, it was impossible to determine satisfactorily the relations of the spinal Vth tract; however, it is undoubtedly superficial and much as in *Amia*.

The peculiar interest attaching to *Acipenser* (or other stur-

[1] "Die innige Verbindung, welche zwischen Cerebellum und Medulla oblongata bei primitiven Formen nachzuweisen ist, berechtigt die Vermuthung, dass wir es hier mit einem primitiven Character zu thun haben. Es erscheint demnach denkbar, dass das streng von der Oblongata differenzirte Cerebellum der höheren Wirbelthiere durch allmähliche Reduktion der Cerebelargebilde der Oblongata und durch eine allmähliche Koncentration dieser Gebilde im differenzirten Hinterhirne der höheren Wirbelthiere entstehen konnte." etc. Goronowitsch, p. 539.

geons) led me to examine the oblongata and especially the "lobus trigemini." As described by Goronowitsch there occurs dorsad of the cerebellar crest in the region of the VIIIth nerve and extending cephalad, an area of cells and fibers from which springs a nerve root (his *Trigeminus II dorsalis*). Immediately beneath the cerebellar crest issues another root of coarse fibers, clearly VIIb of *Amia*. The fibers of the dorsal root are indeed finer than those of the more ventral, but the difference is not nearly as marked as one might suppose, and as compared with the fibers of VIIaa, they are coarse. *Trig. I ventralis* of Goronowitsch was found upon examination to spring, in several rootlets from a motor nidus and not from the posterior longitudinal fasciculus, representing the motor portion of the Vth in *Amia*. The tract named by Goronowitsch "system γ" is clearly both from the description and the examination of the brain, what was found in *Amia* to be part of the spinal Vth tract, and from the examination of *Acipenser* the same seems to be the real destination of this tract there. System γ would not in any case be more than a partial homologue of the secondary vago-trigeminal tract of the teleostean brain. The fact remains, that *Acipenser* possesses a root of comparatively coarse fibers, which is not present in *Amia* and *Lepidosteus*, springing from a portion of the brain which is also apparently lacking in these two forms. This the "lobus trigemini" will prove, I believe, to be the homologue of the structure of the same name in Elasmobranchs.

Teleostei. As compact a discussion as possible of these regions and their modifications in teleosts follows.

Nematognathi. In view of the belief of some that the Nematognathi among teleosts are the most closely related to Ganoids, we might expect *Amiurus* to show in the structure and morphology of its brain, some indications of ganoid affinities, but as has been already stated by C. J. Herrick '91, it presents as purely teleostean characters of the brain as other bony fishes, although simpler in some respects than many,—perhaps most,—other Teleosts. The morphology of the oblongata and the more striking and important structural features have been pre-

viously discussed by Wright and need only be referred to in so far as they affect the dorsal region. Except for the teleostean characteristic of greater concentration of fiber tracts into distinct bundles, the oblongata of *Amiurus* would be directly derivable from the ganoid type as presented in *Amia* by a concentration of structure and a great development of the fasciculus communis system, especially the preauditory portion of its root, and the limitation of the acusticum to the dorsal side. To harmonize the relations here with those in other forms and illustrate points already made, the following may be noted.

The enormous enlargement of the dorsal cornua of the myel as the oblongata is approached, is a condition apparently quite universally present in "fishes;" in *Amiurus* the changes closely compare with those in Cyprinoids as described by Mayser. Figures 7-10 will give an idea of how clearly the relation of parts is indicated in *Amiurus*. Caudad of the oblongata occurs the enlargement of the dorsal cornua; these, with the surrounding fibers move laterad and the fasciculus communis systems appear on the dorsal portion, the two sides connected caudad of the metatela by the *Commissura infima Halleri*. The dorsal cornua rapidly diminish and about them on the dorsal and lateral sides the fibers of the spinal Vth tracts appear,—pushed ventrad by the greatly developed fasciculus communis systems (lobi vagi) which now occupy the dorsal region of the oblongata. Cephalad of the Xth there appears at the side of the oblongata a new structure, which spreads ventrad covering ectally the spinal Vth tract and soon is capped on the dorsal side by the cerebellar crest. This is easily recognized as the homologue of the acusticum of *Amia*, the *tuberculum acusticum* of *Wright*. In *Amiurus* and indeed other teleosts, it is not purely dorsal but extends laterally over the oblongata, submerging the spinal Vth which until the appearance of the acusticum, was superficial. The pre- and postauditory portions of the fasciculus communis are differentiated into the so-called "trigeminal" and "vagal" lobes; the former are enormous and dove-tail into each-other; they extend dorsad and displace the acusticums laterally (Figs. 5 and 11), but no fusion occurs,—at least not in the individuals

examined, although it may possibly be found in older specimens.

Of the cranial nerve roots little need be added to Wright's account. The sensory portion of the Xth springs from the lobus vagi in a single large root, passing dorsad of the spinal Vth. A small contingent of fibers from this tract was easily demonstrable. The motor portion of the vagus springs from its nidus just ventrad of the fasciculus communis in 8-10 small roots which pass on the ventral side of the spinal Vth. A root bundle of the Xth composed of coarse fibers of characteristic appearance, undoubtedly the lateral line nerve, passes cephalad from the Xth accompanied by a fine fibered bundle (IX) which enters the brain first, penetrating the acusticum to reach the fasciculus communis (Fig. 24), while the coarse fibered root enters the acusticum just ventrad of the cerebellar crest and may be traced cephalad some distance. From the lobus trigemini arises an enormous root, VIIaa, the "dorsal geniculate root of the Vth;" and close to it there arise, (1) from the acusticum dorsad of it a root which as Wright determined innervates the neuromasts (VIIb), (2) caudad and ventrad, the VIII, and (3) the facial proper arising in its usual manner and leaving the brain ventrad at about the level of VIIaa. A slight distance cephalad there arises the Vth proper, composed of the spinal Vth and two bundles from the trigeminal motor nidus. No mesencephalic origin for any of the fibers has as yet been recognized in *Amiurus*.

It is not at all difficult to recognize here the same components present in *Amia*; most notable is the enormous development of VIIaa. It is to be noted also that in *Amiurus* there occur no fusions across the meson, such as are found in other teleosts, neither of the lobi trigemini nor the acusticums; what Wright described as a fusion of the latter is the decussation of the fibers of the cerebellar crest in the cerebellum. The massing of the fasciculus communis system and especially the development of the preauditory part as the lobus trigemini has displaced the acusticum from its typically dorsal position and crowded it to the side. By a reduction of the fasciculus communis element and a cephalo-caudal stretching of the oblongata,

especially of the acusticums, the form might be easily reduced to that of the following order.

Haplomi. In *Esox* and *Fundulus*, the two representatives of this order examined, the conditions are even somewhat more satisfactory than in *Amiurus*, since the communis system is much more weakly and evenly developed. The exact caudal limit of this system is in *Esox* somewhat difficult to determine exactly from the material at hand. A common mesal area representating the *comm. infima Halleri* appears between the dorsal cornua and is soon divided into the paired tracts at the caudal end of the metatela. The Xth arises by 4 or 5 closely associated roots which contain both sensory fibers from the fasciculus communis and motor from the vagal nidus (*ni*). These all pass ventrad of the spinal Vth. Cephalad of these the acusticum appears in transection dorsad of the spinal Vth, and is soon capped by the cerebellar crest. An isolated root (IX?) composed of communis and motor components enters, penetrating the acusticum, cephalad of which and near the entrance of the lateral line root another small root from the communis system and motor nidus enters. The lateral line nerve enters the acusticum immediately beneath the molecular layer. The VIII nerve springs from the acusticum by 2 (or 3) roots, dorsad and cephalad of which arises VIIb, followed by VIIaa and VIIab, the former at about the same level, the latter farther ventrad. The spinal Vth leaves the brain a short distance cephalad accompanied by motor strands (2 or 3) from the trigeminal motor nidi.

Fundulus, in the structure of its oblongata closely agrees with *Esox*; the caudal limit of the fasciculus communis systems was clearly defined and easily distinguished from the dorsal cornua. The Xth arises in 3 divisions, the sensory fibers (from the communis system) dorsad and the motor ventrad of the spinal Vth. Isolated sensory and motor roots (IX?) enter farther cephalad, the former from the fasciculus communis, the latter from a motor nidus. The lateral line nerve is small; its relations are as already described. VIII, VIIb and VIIaa leave the brain very near each other and the Vth follows closely.

In these two fish the fasciculus communis system is evenly developed. At the exit of the Xth it is dorsal but it is soon displaced by the acusticum. There is no "lobus trigemini"; VIIaa develops as the fasciculus communis diminishes and has a short cephalic course before leaving the brain. In *Fundulus* this root and also the entire communis system is somewhat better developed than in *Esox*. In *Esox* there is a division into two quite well defined regions. No vagal fibers were seen to spring from the spinal Vth. No Weigert preparations were made and on further study no doubt such a component will be found to exist. Important it is in view of the conditions in the forms to be mentioned, that in these, as in *Amiurus*, there are no secondary fusions of endymal surface in the oblongata (Fig. 20).

Acanthopteri. Four spiny-rayed teleosts were studied, representatives of as many families,—*Roccus*, *Perca*, *Cottus*, *Lepomis*. In these one important general difference from the forms hitherto mentioned occurs in the dorsal fusion of the acusticums across the meson (Fig. 19). It extends from about the region of entrance of the lateral line nerve cephalad nearly to the exit of the VIIth. It is substantial, involving the molecular layer and the portion beneath it, obliterating the endyma and giving passage to fibers from side to side. Aside from this the relative development of the regions of the oblongata is much as in the Haplomi. The communis system is but slightly developed and there is no differentiation of pre- and postauditory portions. A few words may be said in description of each separately.

In *Roccus*, (Fig. 23) the fasciculus communis system appears some distance caudad as a mesal area between the dorsal cornua. The development of the spinal Vth tract upon the dorsal and lateral sides of these and its direct continuity with the dorsal fibers of the myel are very clearly shown.

The Xth arises by 7-8 poorly defined roots which pass ventrad of the spinal Vth. It derives a distinct component of fibers from this tract. The lateral line nerve enters in the characteristic place just beneath the cerebellar crest, and at the same level a fine fibered root from the Xth which passes cephal-

ad in company with a portion of the VIII, enters, going dorsad of the spinal Vth to the fasciculus communis system. VIIaa is well developed and its deep course and origin are as in *Esox*. A slight endymal fusion occurs between the caudal portions of the fasciculus communis systems. It is insignificant.

In *Lepomis*, as in *Roccus*, the spinal Vth tract is very prominent on the surface of the dorsal cornua. The roots of the Xth pass ventrad of the tract and derive a component from it. The isolated cephalic vago-glossopharyngeal root enters just caudad of the lateral line nerve and near the beginning of the fusion.

In *Perca* (Figs. 12 and 19) also, the spinal Vth tract is strongly pronounced, the fibers being grouped in two bundles. The Xth nerve passes ventrad of it and receives a strong strand of fibers from its dorsal division (Fig. 12). The cephalic root enters as before described, dividing the spinal Vth tract in its passage to the fasciculus communis.

In *Cottus* no spinal Vth component to the Xth was recognized with certainty. The fusion of the acusticums was not as strong as in the other three forms.

In all the origin of VIIaa was as already described in *Esox*, having a cephalic course after its formation before leaving the brain. The fasciculus communis system was most developed in *Roccus* and *Lepomis*, where, as in *Esox*, there was an indication of two regions, dorsal and ventral.

Isospondyli. A single species belonging to this order was examined, the alewife, *Clupea pseudoharengea*, and the study bestowed upon it at present only suffices to permit the general relations of these regions being mentioned. A strong fusion of the acusticum systems occurs and since these are drawn cephalad under the cerebellum and the cerebellar crest is also somewhat concentrated, the appearance produced is that of two lobes of the cerebellum. The fasciculus communis is but weakly developed, especially the preauditory portion of it. The Xth arises by three large roots which penetrate the spinal fifth tract to reach their central connections, the two more cephalic also passing through the acusticum which extends caudad to

this level. The lateral line nerve is small, but yet unexpectedly large when it is remembered that the lateral canal of the lateral line system is short; doubtless neuromasts in the epidermis occur. Cephalad of this root, one of medium size springs from the fasciculus communis system (IX?). VIIaa is very small; VIIb rather large.

Eventognathi. In the Cyprinidae we encounter forms already well known from the monograph of Mayser [1] and in them and the Catostomidae there exists so far as known to me, the greatest complexity of the oblongatal region among teleosts. The secondary fusion of the oblongata, involving in the two orders last mentioned the acusticum only, here includes also the preauditory portion of the fasciculus communis system and there is produced the *tuberculum impar* of earlier authors. For this fusion the great development of the fasciculus communis system and the nerves issuing from it, seems probably, in a degree, responsible; an increasing growth of this system under the limitations which the fusion of its cephalic portion imposes, produces apparently the monstrosity of the carp and sucker brain. A displacement of the acustic systems is also a necessary accompaniment of the growth and eversion of this inner region, and instead of being dorsal, it has been crowded cephalad, although when other things are considered, this may be shown to be more apparent than real. In the brains examined, however, a series of increasing complexity may be easily formed, which further studies will undoubtedly make more complete.

To Mayser's account of the cyprinoid brain little more can be added than to speak of the different modifications of the regions and their relations to the cranial nerves. No microscopical study of the carp brain has been made and Mayser's account has been taken as the source of information. *Notemigonus* is the simplest of the cyprinoid brains examined by the writer. The caudal beginning of the fasciculus communis systems is

[1] Mayser examined many teleosts besides cyprinoids, and in the absence of any comparison or statement to the contrary, it has been assumed by some (and naturally) that the conditions described by him were typical of teleosts generally.

easily recognized and its development though great is not excessive (Fig. 14.). It soon assumes a dorsal position in the oblongata and the Xth nerve arises from it in two main divisions, both passing dorsad of the spinal Vth tract. Cephalad of the Xth the acusticum soon begins upon the side of the oblongata and at the caudal end of the fused preauditory portion of the fasciculus communis systems, the cerebellar crest appears. Two isolated fasciculus communis roots enter, one a short distance cephalad of the mass of the Xth nerve, the other (IX?) near the level of the entrance of the lateral line nerve (VIII post., Mayser). The *tuberculum impar* is a single mass, although a mesal groove on its dorsal side indicates its paired composition. From it fibers concentrate to form VIIaa which continues cephalad for a short distance as a round bundle after the tuberculum impar has been replaced by the fused acusticums. The roots in this region are much as in other forms and as described by Mayser, except that he recognized no root from the "tuberculum" acusticum except the VIIIth; VIIb and VIIaa as before, emerge together, VIIaa cephalad, VIIb caudad. The point of interest in *Notemigonus* is that the pre- and postauditory portions of the fasciculus communis system are directly continuous as in the teleosts before described and the postauditory or vagal portion does not overlap the tuberculum impar. The caudal limit of the communis fusion and the cerebellar crest upon the acusticum is nearly the same.

In *Notropis*, the common shiner, the vagal lobes are somewhat more developed and extend cephalad slightly around the tuberculum impar, so that in the same transection there is included the tuberculum impar, lobus vagi, and acusticum. In *Exoglossum* this is yet more marked and the structure is more carp-like (Fig. 26). The Xth as before, passes dorsad of the spinal Vth, occasionally breaking through it. An isolated cephalic fasciculus communis root (IX?) enters caudad of the entrance of the lateral line nerve.

In the carp the development and eversion of the vagal lobes (postauditory portion of the fasciculus communis) is much greater so that the spinal Vth is ventral rather than lateral and,

as Mayser shows, may be easily seen upon the ectal surface until the acusticum covers it up. A drawing of the dorsal aspect of the carp oblongata is shown in Fig. 2. (Comp. Fig. 4, of *Perca*.)

In *Catostomus* (Figs. 21, 22, 25) the development of the vagal lobes and tuberculum impar (fasciculus communis system) is carried a step farther. The vagal lobes are enormous and together with the cerebellum quite conceal the tuberculum impar and acusticums. The very large sensory portion of the Xth arises in two divisions and the motor farther ventrally but dorsad of, or breaking through the spinal Vth tract (Fig. 21). Farther cephalad another quite large root enters the lobus vagi after the acusticum has already appeared in transection (IX?). Figure 22 shows the overlapping of regions and Figure 25 may be compared with the similar section of Perca Fig. 19.

In none of the Eventognathi has a component of vagal fibers from the spinal Vth tract been certainly detected.

In General. The acusticum system in all these teleosts is not only dorsal but extends laterad over the side of the oblongata covering and submerging the spinal Vth tract which until its appearance is superficial. The general description of the structural appearance of the fasciculus communis in *Amia* applies also to teleosts.

In some forms the zone of small cells next the endyma is quite thick, six or seven cells deep. In *Amiurus* this zone is wanting and the cells are quite evenly dispersed through the region. When the system becomes greatly developed the dorsal and lateral growth involves structures covered primarily (typically) by endyma until they become ectal and pial. Closely associated with the communis system is the vagal motor nidus. In *Amia* (Fig. 16) and the simple teleosts (Figs. 10, 12, 13, 23, 24) this lies ventrad of the fasciculus communis and is easily recognized as forming no part with it, but in the cyprinoids (and suckers) the eversion of the fasciculus communis involves this region as well (Fig. 21.). Thus Mayser recognized in the lobus vagi of the carp 5 zones or layers,—(1) fibers of the va-

gus, (2) gelatinous substance, (3) secondary vagus tract, (4) motor nidus, (5) endyma. Between (1) and (2) might be interpolated the zone of small cells. Of these five layers only the first two would belong to the communis system; the others are involved because of the modification of this region. The tract recognized by Mayser and termed the "secondary vago-trigeminal tract" appears quite constantly in the teleosts (examined). It is a tract ventrad or ventro-mesad of the spinal Vth tract, formed by fibers coming from the fasciculus communis and going cephalad to a nidus at the base of the cerebellum (Rindenknoten, Mayser) which communicates with its fellow by a dorsal commissure through the cerebellum.[1]

The relation the issuing vagal fibers bear to the spinal Vth is clearly due to mechanical advantage and the course they take is regulated by the position and development of their oblongatal center.

The communication of the two fasciculus communis systems caudad of the metatela, spoken of as the "*commissura infima Halleri*" appears constant. The caudal limit of the communis system was not always easy to determine. In most however (especially *Amiurus* and *Perca*), its limit was apparent, and Mayser's view that this as well as the spinal Vth was continuous with the gelatinosa of the myel, is questionable.

The distribution of the fibers of the root spoken of as the "lateral line nerve" has not been determined for any of the teleosts. It is, however, the undoubted homologue of the lateral line nerve in *Amia* and *Acipenser* in which its distribution has been shown. There is constantly found an isolated root from the fasciculus communis near or slightly caudad of the lateral line nerve, which I am inclined to think represents the sensory portion of the IXth. The relation in *Amiurus* resem-

[1] Mayser believed the secondary vago-trigeminal tracts decussated through the cerebellum. From the conditions in *Amiurus*, which has been more especially studied, this does not seem to be the case; the two tracts terminate and the nidi in which they terminate are connected by a dorsal commissure through the cerebellum.

bles that in *Amia* and the correctness of the homology seems probable.

An estimate of the absolute amount of development these systems have undergone in the Eventognathi and the extent to which it alone has influenced the morphology of the oblongata appears as yet impossible, because all the necessary data are not known. A simple concentration of structure whether due to intrinsic or extrinsic causes, might in some cases appear as a greater development. The fusions, also, are unexplainable until a study of the development of the oblongata has been made in which are carefully considered the conditions of growth and the relation of the oblongata to the cranial wall and ear.

CONCLUSION.

To sum up, then, the result of the foregoing observations, the morphologically dorsal region of the oblongata is composed of three systems, the spinal Vth tract, the fasciculus communis system and the acusticum. The first is the direct representative in the oblongata of the dorsal horn and associated columns of alba of the myel; the other two regions appear peculiar to the oblongata, the first typically more mesal, the second dorsal and capped by a caudal extension of the molecular layer of the cerebellum. The spinal V furnishes all (?) the sensory fibers of the trigeminal nerve and, in *Amia*, *Perca*, *Amiurus*, *Roccus* and *Lepomis*, at least, a small contingent of fibers to the Xth (possibly in Ganoids (*Amia*), to the seventh also). From the *fasciculus communis* spring the larger part of the ganglionated IX and X and VII; while from the tuberculum acusticum, the nerves supplying the ear and the organs of the lateral line system. In *Amia*, and it is probably so for other Ganoids, the spinal V is superficial, in other words the acusticum is wholly dorsal. In Teleosts the acusticum also extends laterad covering and submerging to a greater or less extent the spinal fifth tract. The first condition, that in *Amia*, is evidently the simpler. In Urodeles and *Petromyzon* (Ahlborn) the spinal (ascending) V occupies a superficial position. The results of His and Minot on

the development of the oblongata of the human brain show a similar submergence of the fasc. solitarius, at first a superficial tract, by the ventral growth of dorsal regions (Rautenlippe),[1] and I have no doubt that when the development of the oblongata in Teleosts is studied with this point in view, a similar change will be found to take place here and at some stage the spinal V tract to be superficial as in Urodeles and Ganoids.

Among Teleosts there exist wonderful modifications in the development of these systems. The simplest condition is found in the two representatives of the order Haplomi which were examined, *Esox* and *Fundulus*, where the regions have as great a cephalo-caudal extension as in Ganoids and no fusions occur. In the Acanthopteri there is a fusion of the tubercula acustica across the meson, constant in the representatives of the four of its families that were examined. In *Clupea* the acusticums are fused and more concentrated, so that the appearance is that of a lobe of the cerebellum. In the representatives of the other two orders, there is a more or less marked development of the *communis* system, especially of the preauditory portion of it, together with a more or less evident concentration of oblongatal structures (cephalization) which has not yet been properly estimated. *Amiurus* is simplest, with no secondary fusion of any portion of the oblongata, although the preauditory portion of the fasciculus communis tract is greatly developed. In the Eventognathi there exists an increasing complexity in the structure of the fasciculus communis, and fusion of the cephalic end (preauditory), of the two tracts as well as of the acusticums occurs. In *Notemigonus* the relation is simplest since here the lobi vagi do not overlap the fused lobi trigemini as occurs in other cyprinoids, notably *Cyprinus*. In the Catostomidae, the development is more marked. Here (*Catostomus*) the enormous lobi vagi extend cephalad over the lobi trigemini so as to nearly or quite conceal it and the fused acusticums, and there is a

[1] "Within a few days the Rautenlippe unites with the main fold of the zone and continues to grow toward the median ventral line passing outside of the tractus solitarius, which thus becomes buried, and, instead of lying superficially, is thereafter deep below the outer surface." Minot, p. 666.

third though small fusion of the lobi vagi. It is a difficult matter to represent by diagram the successive degrees of complexity in the teleosts which lead up to the sucker (*Catostomus*) as their climax. It has however been attempted in Figs. 30-33. When other orders and families of teleosts are examined other modifications and degrees of development will doubtless be found to exist, and in other families of the orders represented here; while in other genera of the families, conditions may be found which will bridge over the differences between the families or orders, so that any generalization from the relations so far found constant, is unsafe.[1] The various developments of the nerve centers are too clearly dependent on the extent and functional activity of the regions or organs innervated to have much morphological value attached to them. The cause of the fusions that occur seems a difficult matter and no attempt has been made to determine in how far the interference of the cranium or ear during development may be responsible. Surely however from such a form as *Amiurus* with widely separated acusticums, it would be hard to derive a cyprinoid with fused acusticums and lobi trigemini.

Strong's work on the cranial nerves of Amphibia has been previously mentioned as the direct inspirer of these observations and it seems to the writer a most helpful step toward the comprehension of the cranial nerves of vertebrates in offering grounds for the homologization of the nerve roots throughout the vertebrate series, and thereby the regions of the oblongata with which they are associated; and in the determination of the components of the nerves, their origin and peripheral distribution, to assist the facts of development in the solution of the problems of the morphology of the vertebrate head and

[1] A careful study of the brain of the different orders and families of the teleostei has never been made and seems to be a piece of work much needed. Mayer undertook such a study of the teleost brain to make it the base of classification. His work was evidently superficial and his figures indefinite or incorrect. The Herricks in this country have done much in the study of the teleost brain. The bony fishes would certainly offers a good field for testing the value of the brain in taxonymic work. The results so far gained suggest that some interesting results may be gained.

the comparison of spinal and cranial nerves. Strong's conclusions as to the components of the cranial nerves of Ichthyopsida may perhaps be best given in his own words: "We have seen that in the cranial nerves of the higher fishes there are three kinds of cutaneous nerves distinguishable by peculiarities of their fibers, of their distribution, and of their internal origin, *i. e.*, (1) mixed fibers of a general cutaneous character continuous with the posterior columns of the cord, (2) coarse fibers innervating the lateral line organs and terminating centrally in the differentiated tuberculum acusticum, and (3) fine fibers innervating the terminal buds (coarse in Selachians and innervating the ampullae?) and terminating centrally (principally) in the lobus trigemini. The latter, *i. e.*, (3), is possibly not completely differentiatiated. Among the Cyclostomes, it seems probable that this specialization has not been carried so far, but this is not yet sufficiently known." In addition and disregarding here the motor (non-ganglionated) components was recognized the *fasciculus communis* component, composed of fine myelinic or amyelinic fibers which constitute the (visceral) nerves of the alimentary tract. Speaking of its great development in fishes, he says: "Its great development in fishes is correlated with the development of the gills, and where these are in process of reduction or lost it is correspondingly reduced" (p. 190). Thus then in addition to the motor nerves, there exist in the cranial nerves, components as follows:—(a) general cutaneous, (b) lateral line, (c) end-bud, and (d) splanchnic; and these having their central connections in or through (a) the ascending V (spinal V tract), (b) tuberculum acusticum, (c) lobus trigemini and (d) lobus vagi— fasciculus communis.

In regard to the relation of the last two regions, the accounts of different writers introduced difficulties that prevented conclusions at all definite being reached. The difficulty, upon a study of the oblongata, shows itself to be due largely to the careless application of the same term in teleosts and elasmobranchs to structures which are not homologous, and for this obscuration both Goronowitsch and Mayser appear in a degree

responsible. Goronowitsch, in the readiness with which he recognized the fibers arising from the so-called lobus trigemini in Acipenser as fine as compared with the fibers from the dorsal tracts, favored by his determination to find in the cranial nerves the dorsal and ventral roots of the spinal nerves; and Mayser, in applying (first) the name lobus trigemini previously used in the elasmobranch brain to a structure in the cyprinoid brain without determining their complete homology.

Under such circumstances attempts to completely homologize the nerves in Ichthyopsida must fail without a recognition of this trouble, and as soon as it is recognized many points before inexplicable are cleared up.

In Elasmobranchs there exists upon the dorsal side of the oblongata an elevated region which is simply a continuation caudad of the *corpus restiforme*, and to this the name of lobus trigemini was quite generally applied (by Miklucho-Maclay; Viault, Rohon, Gegenbaur). Since it is a direct continuation of the corpus restiforme, that name, as used by some (Stannius) also includes it. It is partially covered by a caudal extension of the molecular layer of the cerebellum which also covers the dorsal tracts laterad of it. Beneath it a large nerve root arises, the most dorsal of the nerves of the V-VII complex. This is undoubtedly the nerve from the corpus restiforme of Stannius innervating the 'mucous' canals. Ewart describes the most dorsal of the nerves distributed to the lateral line system in *Laemargus* as the *ophthalmicus superficialis*. "This nerve arises by a large root from the so-called trigeminal nucleus which occupies the most dorsal portion of the medulla." It communicates freely with the buccal. VIIc of Strong '94 in *Galeocerdo* seems to be the same root.

It seems probable that the "lobus trigemini" of *Acipenser* (and other sturgeons, probably) is the same structure found in sharks and the nerves are homologous. In examining transections through this region of the *Acipenser* brain, the impression was strong that there had been a partial folding in of the cerebellar crest and fusion of the two surfaces. The occurrence of large (Purkinje) cells on both sides of the cerebellar crest

strengthens the belief. The comparision of sections of *Acipenser* with the figures of Rohon and Sanders of the corresponding region of the shark brain indicates that the structure is the same in both. The homology entertained, but rejected, by Strong of *Trig. II dors.* with VIIu of Osborn in *Cryptobranchus* (my VIIb′ in *Necturus*) springing from an island of ground substance upon the dorsal side of the oblongata, is perhaps worthy of being further considered. It was rejected by Strong mainly (apparently) because the conflicting use of "lobus trigemini" necessitated other homologies. Were it correct there would persist in reduced state in shark-like ganoids and the larger urodeles the remnant of an elasmobranchian structure (*corpus restiforme?*). Therefore, not to devote more space to it here, it would seem to me that a consideration of the relations of the "lobe" and its nerve root and comparison with ganoids leaves it highly probable that the root from the lobus trigemini in sharks is the homologue (in part) of VIIb Strong, the lateral line component, and the "lobus trigemini" will prove on investigation to be a modified portion of the acusticum system.

In teleosts the lobus trigemini is but the enlarged cephalic portion of the fasciculus communis system; fused in the Eventognathi, unfused in *Amiurus* (Nematognathi?), while in other teleosts examined no lobus trigemini as a special hypertrophy exists. The root from this lobe, the "dorsal geniculate root of the Vth" is the homologue of VIIaa in Amphibia and is present whether a lobus trigemini as such exists or not. This is not saying, however, that they are in each case exactly equivalent.

In view of the foregoing statements the following may give help on some of the points and problems raised by Strong. In the first place, the nerve of Goronowitsch from the "lobus trigemini" of *Acipenser* is not the homologue of the geniculate V of teleosts which *is* the representative of his dorsal root of the seventh (Frd.) from the fasciculus communis (lobus vagi). The recognition of TIId. as a lateral line root clears up the difficulties occasioned by its distribution to the ophthalmicus su-

perficialis VII, buccal and otic and hyomandibular. We should expect the root from the "lobus trigemini" of sharks to be coarse fibered if it innervates the lateral line organs. If Ewart is correct, the Ampullae of Lorenzini would be more closely related to the lateral line organs and not representatives in Elasmobranchs of end-buds of higher forms.[1] In Amphibia, though no differentiated lobus trigemini exists, it is represented morphologically by the cephalic portion of the fasciculus communis in connection with the preauditory root from this tract, VIIaa Strong. Of the three alternatives offered in the interpretation of the lobus trigemini and the innervation of the end-buds, when it is recognized that the lobus trigemini and lobus vagi are but differentiated parts of the fasciculus communis tract, the first two lose their point and the third, which Strong regarded as most probable, stands, with this modification, that the lobus vagi and lobus trigemini, of teleosts, instead of being distinct structures partially equivalent, are but the differentiated pre- and postauditory parts of the same system. The question of the innervation of the end-buds remains as difficult and as far from a satisfactory solution as before. It is quite possible that, as Strong suggests, two kinds of fibers from different portions of the fasciculus communis tract may have distinct distributions—one end-bud and the other splanchnic.

The view apparently entertained by Allis ('95) that the fasciculus communis gives rise to fibers distributed exclusively to end-buds is certainly not correct, since very much the larger part of the sensory (ganglionated) fibers of the vago-glossopharyngeal spring in *Amia* (and in other Teleostomes) from that tract.

That the end-buds on the head of teleosts receive their innervation from both pre- and post-auditory portions of the tract is undoubtedly true from the investigations of Wright, Allis and Strong. In *Amiurus* (Wright) and the carp barbel end-buds in the skin of the head are plentiful, and doubtless when other cyprinoids and suckers are examined the end-buds

[1]Since they are innervated by the same nerves as are the lateral line organs. See also Cole, '96.

will be found equally or more abundant, and in forms with a weak development of the fasciculus communis system, they will be few or wanting in the skin. In *Amia* the preauditory communis component forms the palatine nerve and contributes fibers to the *rami maxillares inferior* and *superior* which go to regions where end-buds occur (Allis '95).

In *Amiurus* (Wright '84) from the fasciculus communis (Lob. trig.) component are derived the most of the fibers of the (1) *ramus lateralis trigemini*, (2) the *ramus ophthalmicus profundus*, from which the nasal barblets receive their innervation, (3) the *ramus maxillaris*, which innervates the large maxillary barblet and (4) the *ramus mandibularis*, innervating the mental barblets, and (5) the palatine and cutaneous palatine nerves. These facts, while they indicate the innervation of end-buds from the fasciculus communis component, raise many difficult questions bearing on the basis of homology of cranial nerves in higher and lower forms. While the lobus trigemini root was considered as part of the Vth, the distribution of its fibers to form such recognized trigeminal nerves as the *ophthalmicus profundus* and *mandibularis* and *maxillaris* would present no great difficulties; but they do appear as soon as it is recognized that the so-called geniculate root of the Vth of teleosts is the homologue of VIIaa (Strong) of Amphibia. In *Amia* the difficulty is as great as in *Amiurus*.

It is however only when the nerve is regarded as a unit with constant central connections (roots) and constant branches (rami) that the difficulty has full force. Certainly suggestive in this connection is Miss Platt's work on the development of the peripheral nervous system in *Necturus*. The idea that may be gained there, [1] broadly stated, is that the central and peripheral

[1] "I will go no further than to add that, as far as the lateral line organs are concerned, their fibers choose the nearest and most direct path to the auditory centers in the brain, which seem to be also the centers of the entire lateral line system, yet both development and comparative anatomy tend to show that it is a matter of little moment whether these fibers enter the brain by one nerve root or another" Platt, p. 505.

"This study, therefore, leads to the conclusion that it is of little moment whether the motor and sensory fibers belonging to the primitive nerves of any

terminations of a nerve fiber are important and constant, while the intermediate course is due more to advantage and may vary. Viewing this from the standpoint of two opposed theories of nerve development and the relation of nerve fiber and ganglion cell, it would be in one case the central and in the other the peripheral region that is the center of growth and constant; that is, in the first case the ganglion would be fixed and the course the outgrowing neurites took to reach their destination would be the easiest or shortest path; in the second case, the nerve fiber, developing as a chain of cells from the ectoderm would take the easiest or shortest course to the appropriate brain-center. It is the latter view of nerve development that Miss Platt's researches support. Discussion of this point will be avoided here; however, it seems that in certain fishes end-buds occur in the skin of the head and in the mouth, and the nerve-fibers entering the brain through a root near the VIIIth nerve, reach their peripheral destination (the end-buds) through numerous nerves. In Amphibia (and higher forms) the end-buds are confined to the mouth and the fibers of this root are distributed only to pharyngeal nerves.

Turning to the brain of Urodeles (*Necturus* etc.) in view of the conditions in fishes (especially *Amia*), it is comparatively safe to homologize the whole region dorsad of the spinal Vth tract with the *acusticum*; this is sustained by the ental origin of the VIIIth nerve and the nerves of the lateral line system. The tailless Amphibia cannot be included yet. Very interesting would be a study of the development and structure of the oblongata of the Anura to determine the regions and their homology. It might facilitate comparison between higher and lower forms which seems unsatisfactory. The entire homology of the fasciculus communis system with the *tractus solitarius* still

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segment enter the brain by one root, by two roots, or by several, the position of the nerve-root being in great measure an expression of the co-ordinate relations which the central nervous system subserves. The morphological value of the nerve comes from without and 'the metameric arrangement of the peripheral nerves is probably not primary, but occurs in adaptation to the segmentation of the structures they supply' (Froriep, 14, p. 590)." Platt, p. 540.

appeals to the writer as unsafe, and the opinion expressed before ('95) is adhered to,—that the data for a full comparison of higher and lower forms are insufficient.

SUMMARY.

The annexed table may summarize the nerve components of the typical forms examined, and the following points recapitulate the general results of the study of the oblongata, illustrated by diagrams of figures 27-36.

1. Three systems constitute the centers for the ganglionated (sensory) nerves of Teleostomes and form the dorsal portion of the oblongata: they are, (1) the spinal Vth tract (system), (2) the fasciculus communis system and (3) the acusticum system.

2. The first gives fibers to the Vth nerve and in *Amia*, *Amiurus*, *Perca*, *Roccus* and *Lepomis* at least, a small contingent to the Xth.

3. The second furnishes fibers to the VII, and IX and X (visceral and end-bud).

4. The third furnishes fibers to the VII and IX and X (lateral line system), and gives rise to the VIIIth.

5. The lobus trigemini and lobus vagi of some Teleosts are but the differentiated pre- and post-auditory portions of the fasciculus communis system.

6. The "dorsal geniculate root of the Vth" of teleosts is the homologue of VIIaa (Strong) of Amphibia.

7. The lobus trigemini of Elasmobranchs it is believed will prove more closely related to the acusticum of ganoids and teleosts; it is clearly the caudal continuation of the *restis* of the elasmobranch brain.

8. No secondary fusions of regions were found in *Amiurus* (Nematognathi) and *Esox* and *Fundulus* (Haplomi).

9. Fusion of the acusticums occurred in the Acanthopteri (4 families) and in the Isospondyli (*Clupea*).

10. Fusion of the acusticums and lobi trigemini is found in the Cyprinidae.

11. *Catostomus* (Catostomidae?) showed in addition to the fusions in the cyprinidae, a fusion of the lobi vagi.

12. The acusticum was in every case covered by a caudal extension of the molecular layer of the cerebellum.

				Amphibia	Ganoids	Teleosts		
NERVE	COMPONENT	DISTRIBUTION	CENTER	NECTURUS	AMIA	PERCA	AMIURUS	CATOSTOMUS
V.	1.	general cutaneous (?)	Sp. Vth. tr.	present strong	present	present, well defined	present	present
	2.	motor (?)	mesen.					
	3.	motor	motor nidus*	*				
VI.	1.	motor	motor nidus					
VII.	VIIab	motor	motor nidus					
	VIIb.	lateral line system	acusticum	present, 2 roots	present, 1 root	present	present	present
	VIIaa	end-bud and visceral (?)	fasciculus communis	"	"	" medium	" very large	" large
VIII.	1 (2)	ear	acusticum	present	present	present	present	present
IX.	1.	lateral line system	acusticum	present	1 root	present	present	present
	2.	end-bud and visceral (?)	fasciculus communis	"	present	" (?)	" small	" (?)
	3.	motor	motor nidus					
X.	1.	motor	motor nidus					
	2.	end-bud (?) and visceral	fasciculus communis	present	present	present	present, quite large	present, large
	3.	general cutaneous (?)	sp. Vth. tr.	"	present small	" medium	present, small	(?)

*The motor nerves are not discussed in this paper, and so are not regarded in the table. The nerve components are given as they were found in the study of the brain in these forms.

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EXPLANATION OF FIGURES.

It is impossible to illustrate this paper adequately since of each form several figures at different levels would be desirable in order to show the gradual changes undergone in passing from the myel into the oblongata and the appearance of the structures discussed in the foregoing. Dorsal views of the oblongata of *Amia*, *Amiurus*, *Perca* and *Cyprinus* are given. Series of 6 figures of transections of the oblongata in *Amia*, 5 in *Amiurus* and two *Perca* are given to illustrate the modifications, to which are added 8 diagrammatic figures of other forms for comparison. All figures are drawn by the aid of the microscope and camera lucida except figures 2 and 5 and the diagrams of plate V. Figure 2 is based upon a photograph.

ABBREVIATIONS.

ac.—acusticum (system).
cbl.—cerebellum.
cbl. cr.—cerebellar crest.
c. d.—dorsal cornu.
cm. i.—commissura infima Halleri.
f. c.—fasciculus communis (system).
l. l.—lateral line nerve.
l. t.—lobus trigemini (preauditory portion of the fasciculus communis).
l. v.—lobus vagi (postauditory portion of the fasciculus communis).
M. c.—Mauthner cell.
Mesen.—Mesencephal.
myc.—myelocœle.
ni.—motor nidus of the Xth nerve.
p. l. f.—posterior longitudinal fasciculus.
sp. V.—spinal (ascending) Vth tract.
s. t. tr.—secondary vago-trigeminal tract.
t. i.—tuberculum impar (fused preauditory part of fasciculus communis systems).
VIIaa.—preauditory fasciculus communis root.
VIIab.—facial proper.
VIIb.—acusticum root.
Xm.—motor root of the Xth nerve.
Xs.—sensory root of the Xth nerve.

PLATE I.

Fig. 1. Dorsal view of the oblongata of *Amia*. The metatela is removed in this and the following aspects since it would interfere with the regions desired to be shown.

Fig. 2. Dorsal aspect of the oblongata of *Cyprinus*. Metatela removed. The brain cavities were injected with alcohol and the vagal lobes (*l. v.*) were apparently somewhat spread apart thereby. The cerebellum has been removed and the cut surface only is seen.

Fig. 3. Lateral aspect of the oblongata of *Amia* to illustrate the superficiality and course of the spinal V tract to the Vth nerve.

Fig. 4. Dorsal aspect of the oblongata of *Perca*. The cerebellum has been removed and the cut surface alone is seen.

Fig. 5. Dorsal view of the oblongata of *Amiurus*.

Fig. 6. A transection through the myel of *Amia* near the brain. The dorsal cornua of the cinerea at this level are considerably larger than in a section of typical myel.

Fig. 7. Transection of the myel of *Amiurus*.

PLATE II.

Fig. 8. *Amiurus*. Transection of the myel (oblongata?) near the metatela showing the enormously enlarged dorsal cornua.

Fig. 9. *Amiurus*. Transection immediately caudad of the metatela through the beginning of the fasciculus communis system (*Cm. i.*). The dorsal cornua have diminished slightly in size and the spinal Vth tract has appeared.

Fig. 10. *Amiurus.* Transection farther cephalad, the fasciculus communis is dorsal (*l. v.*), the spinal Vth and the almost entirely reduced dorsal cornua are displaced.

Fig. 11. *Amiurus.* Transection at the level of the exit of the VIIth roots. Intermediate between this and figure 10 is figure 24 at the entrance of the IX?, showing the developing acusticums.

Fig. 12. *Perca.* Transection of the oblongata at the exit of the Xth nerve. A component from the spinal Vth tract is shown.

Fig. 13. *Amia.* Transection through the myel showing the enlarged dorsal cornua. (Comp. fig. 6 and figs. 15-18.)

Fig. 14. *Notemigonus.* Transection through the oblongata at the exit of the Xth nerve.

PLATE III.

Fig. 15. *Amia.* Transection of the oblongata at the first (recognizable) appearance of the fasciculus communis system.

Fig. 16. *Amia.* Transection farther cephalad near the caudal appearance of the acusticum and the cerebellar crest.

Fig. 17. *Amia.* Transection at the level of the IXth.

Fig. 18. *Amia.* Transection of the oblongata at the exit of the VII-VIIIth nerves.

Fig. 19. *Perca.* Transection of the oblongata caudad of the VIIIth showing the fusion of the acusticums.

Fig. 20. *Esox.* Transection of the oblongata at the exit of the VIIIth.

PLATE IV.

Fig. 21. *Catostomus.* Transection of the brain at the exit of the Xth. A fusion of the vagal lobes is shown. (Comp. figure 14 of the corresponding level in Notemigonus.)

Fig. 22. *Catostomus.* Transection farther cephalad including the tuberculum impar, the acusticums and the cephalic projection of the lobus vagi.

Fig. 23. *Roccus.* Transection of the oblongata at the exit of the Xth nerve.

Fig. 24. *Amiurus.* Transection of the oblongata at the level of the entrance of IX?

Fig. 25. *Catostomus.* Transection of the oblongata farther cephalad than figure 22 where the tuberculum impar has been replaced by the fused acusticums.

Fig. 26. *Exoglossum.* Transection through the oblongata showing slight overlapping of the tuberculum impar by the lobus vagi and the first appearance of the acusticum.

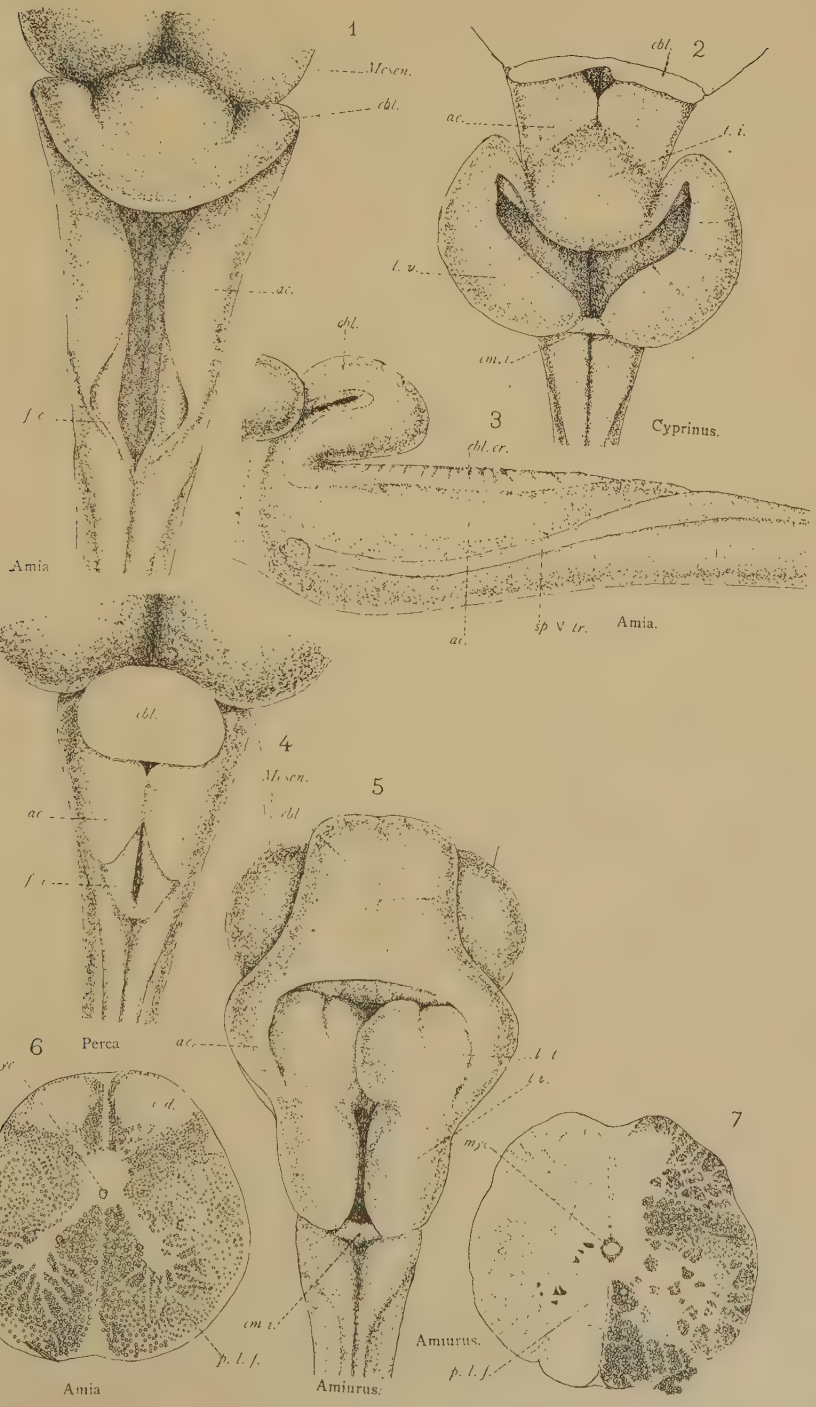
PLATE V.

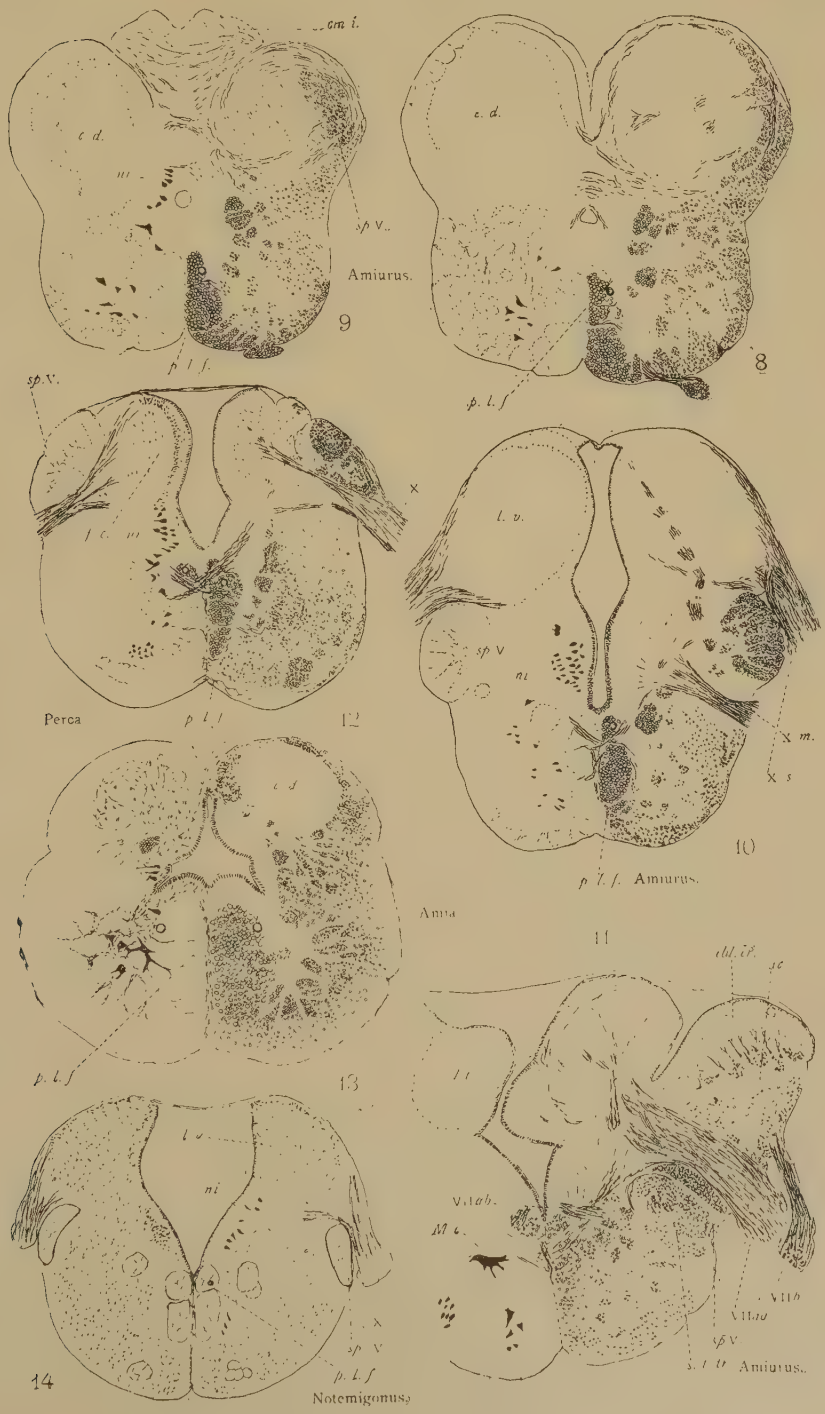
Ten diagrams to illustrate the regions and nerves discussed which are demarcated in different colors.

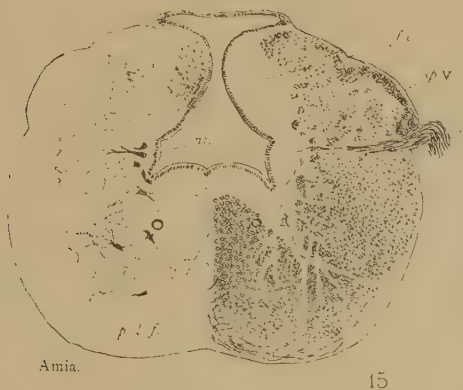
Figs. 27-29. Diagrams of the sensory (ganglionated) oblongatal nerve roots in *Necturus* (Amphibia) *Amia* and *Amiurus.*

Figs. 31, 30, 32, 33. Diagrams of the oblongatas of *Amia*, *Perca*, *Notemigonus* and *Cyprinus* to illustrate the increasing complexity and associated fusions. The left side in *Perca* and *Amia* are shown as though the fasciculus communis system were exposed,—as if the covering part of the acusticum had been dissected away. (Comp. figs. 1 and 4.)

Figs. 34-36. Transections through the oblongata of *Amiurus*, *Amia*, and *Perca* respectively. Fig. 34 caudad of VIIIth; fig. 35 near the IXth and fig. 36 cephalad of the Xth.


1
Mesen.
cbl.
ac.
f. c.
Amia
2
cbl.
ac.
l. i.
l. v.
cm. t.
Cyprinus.
3
cbl.
cbl. cr.
sp V tr.
Amia.
ac.
4
cbl.
ac.
f. c.
Perca
Mesen.
cbl.
5
ac.
l. t.
f. c.
myc.
cm. t.
p. l. f.
Amiurus.
6
myc.
c. d.
p. l. f.
Amia
7
myc.
Amiurus.
p. l. f.


c. d.
sp V.
Amiurus.
9
p. l. f.
c. d.
8
p. l. f.
sp.V.
Perca
p. l. f.
12
L. v.
sp V
x m.
x s
10
p. l. f. Amiurus.
Ameiurus
11
c. d.
p. l. f.
13
l. v.
sp V
p. l. f.
14
Notemigonus
Amiurus.



Amia.

15

16

Amia.

17

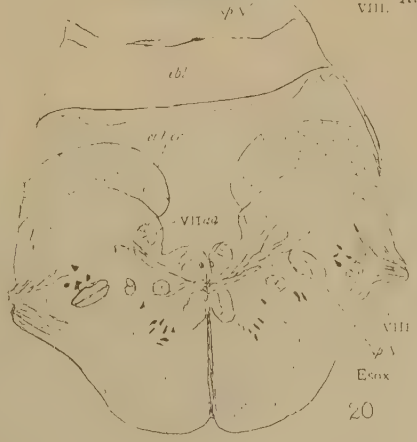
Amia

18

VIII. VIIb Amia

Perca.

19

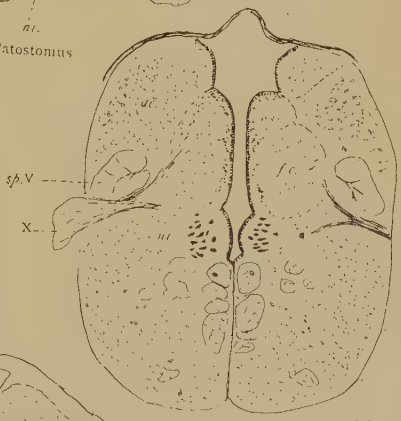


Esox

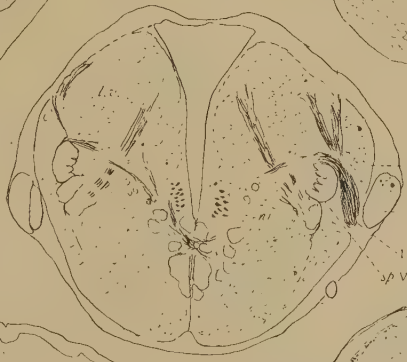
20

21 Catostomus

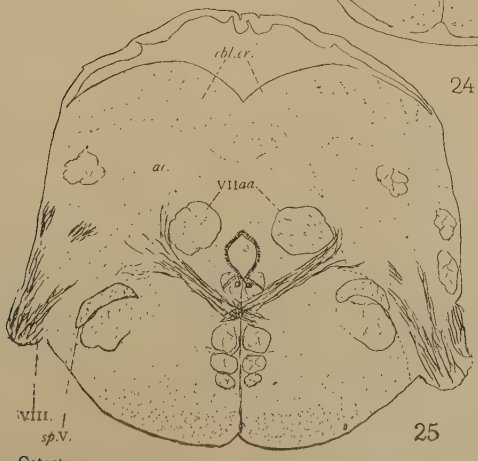
Catostomus. 22



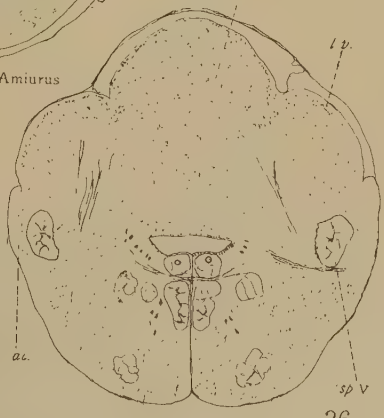
Roccus. 23



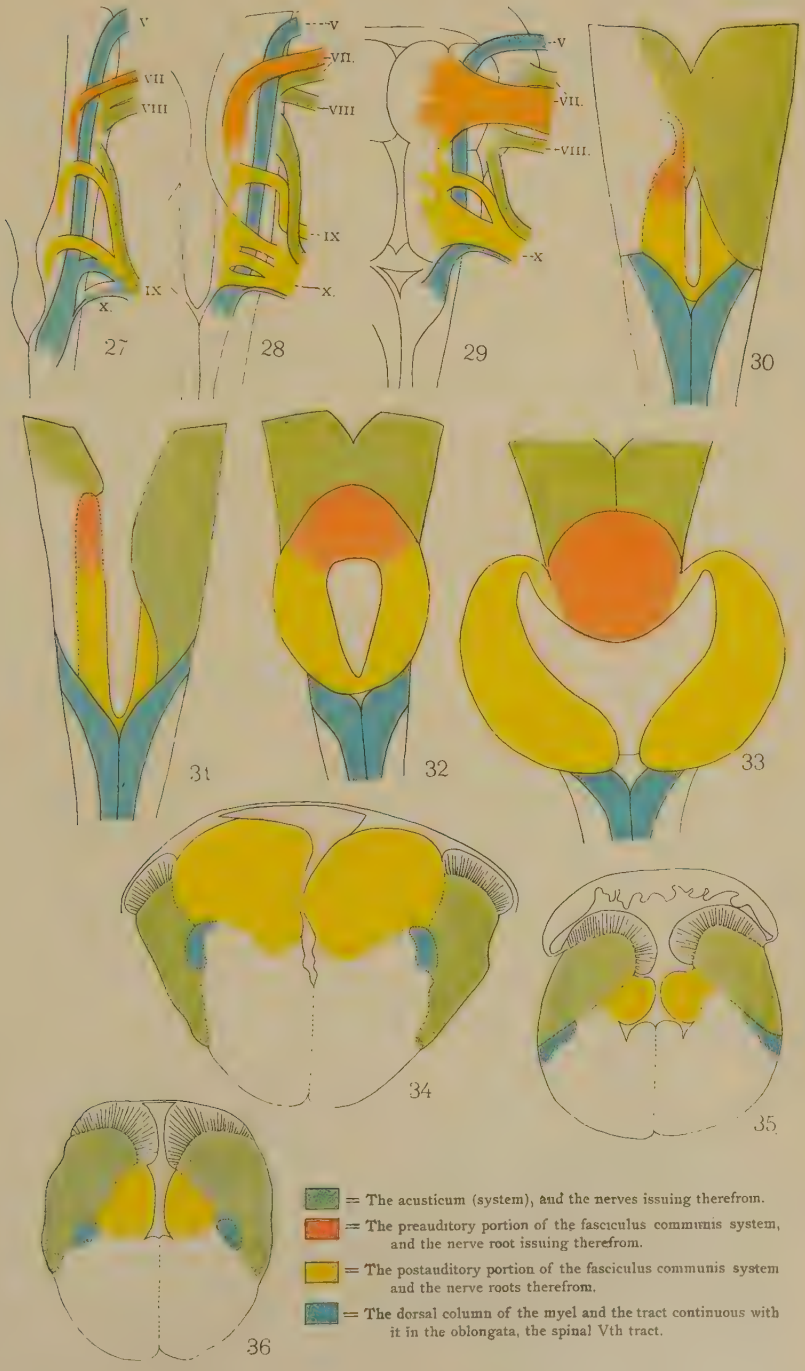
Amiurus 24



25 Catostomus.



26 Exoglossum.


V
VII
VIII
IX
X
27
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36
= The acusticum (system), and the nerves issuing therefrom.
= The preauditory portion of the fasciculus communis system, and the nerve root issuing therefrom.
= The postauditory portion of the fasciculus communis system and the nerve roots therefrom.
= The dorsal column of the myel and the tract continuous with it in the oblongata, the spinal Vth tract.

THE ENCEPHALIC EVAGINATIONS IN GANOIDS.

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(*With Plate VI.*)

The great interest attaching to the extent and interpretation of the membranous roof of the vertebrate brain cephalad of the postcommissure, and the number and significance of the outgrowths occurring in this region may serve as an excuse for the isolated publication of a few facts upon the latter in Ganoids, especially since the presentation of the results of a more general study of the ganoid brain seems somewhat remote.

The new and important points are two: (1) the presence in the adult *Amia* of the first epiphysial vesicle of Hill and its innervation from the left habena; and (2) the existence in *Amia* and *Lepidosteus* of lateral cephalic and caudal extensions of the cavity caudad of the *velum transversum* of Kupffer, constituting considerable diverticula. More emphasis it is felt should be laid on the existence of the "dorsal sack" and the presence of the paraphysis as distinct structures. A word may be added upon the metaplexus in *Lepidosteus* which presents some interesting features in connection with the diverticula from the diatela.

Epiphysis. Great interest has always attached to this structure, so constant in the vertebrate series, as the remnant in a greater or less degree of preservation, of a sense-organ once of importance in vertebrate ancestors. Recently fresh interest has been added by the studies of numerous observers which go strongly to show (though not conclusively as yet, it is felt) the presence of two, or possibly more, evaginations from this region of the brain roof. By Hill, Studnicka, and Locy is entertained the view that it is the more caudal of these, the epiphysis proper, which is most developed in the lamprey and persists

in all craniota in a more reduced state; the cephalic is the "second epiphysial vesicle" in *Petromyzon*, the parapineal organ of Studnicka ('95). It occurs in embryo teleosts and *Amia* (Hill), and in reptiles becomes separated from the brain as the well known parietal eye of lizards. There is, however, no case so far as known to me where they might not be interpreted as but modified parts of the same primary evagination,[1] were it not for the observation of Locy of three pairs of depressions upon the medullary plate of the shark embryo; the first enter the optic evaginations; the second he traced to the epiphysis; while the third pair was lost.

As has been said by others, the need now is the accumulation of facts showing the relations in this region of the brain in a wide range of forms, especially embryologic data which will throw light on the first appearance of these (or this) evaginations in the various forms. It is as contributing a little to the interpretation of these structures that the following is offered. It has just been stated that Hill has already described the existence of two epiphysial structures in the embryo *Amia*. The cephalic evagination (epiphysis I) in embryos of 10 mm. length is an ellipsoid sack lying upon the left side of the epiphysial stalk (epiphysis II); its cavity is connected with the cavity of the brain. Likewise in 13 mm. *Amia* the cavity is in communication with the brain, but in embryos 15 mm. long the connection is severed and epiphysis I lies upon the left side of epiphysis II. It appears that the adult or later embryos were not examined. In *Salmo* (the teleost more especially studied; others were *Catostomus*, *Stizostedion* and *Lepomis*) the connection is severed in 13 mm. embryos; in 25 mm. *Salmo* (160 days old) the cavity is obliterated and in 2 year fish it is recognizable only in

[1] Leydig, Beraneck and Francotte state that two distinct outgrowths from the roof of the diencephal in reptiles occur. Klinckoström, Selenka and Sorensen however think there is but one evagination. Accessory parietal eyes which have been observed in certain lizards appear variable in number and cannot yet be interpreted. Likewise in *Petromyzon*, earlier stages of the development of these structures are wanting and the cephalic vesicle may prove, as believed by some, to be derived from the caudal.

one fish as a small mass of cells lying to the left of the epiphysis (epiphysis II). In adult *Amia*, however, this structure persists as a hollow vesicle closely applied to the left of the epiphysis (Epiph. II) and with it enveloped by the dorsal sack in which they are suspended as by a fold. Epiphysis I lies almost directly dorsad of the supracommissure and receives a strong fasciculus of non-medullated fibers from the left habena (Fig. 1). This point is important since it strengthens the homology of this with the parapineal organ (Studnicka) of *Petromyzon* which has been found to have fiber connection with the left habena.[1]

Lepidosteus (adult) was examined and no trace of the epiphysis I was found although a small cluster of cells in the proper location possibly represented it in much reduced state (as in 2 year *Salmo*, Hill). No trace of it has been found in adult *Polyodon* or *Acipenser*, in which this region was subjected to examination by Studnicka '96 and Goronowitsch. Kupffer does not show it in embryo *Acipenser*.

Dorsal Sack. Goronowitsch, I believe, was the first to employ this term. It has since been employed by Mrs. Gage, Herrick, Humphrey and Wilder, and seems preferable to the other terms applied to this region of the brain, which seems worthy of a distinct name, whatever its morphologic value.[2] It is the cavity included beneath the diatela caudad of the velum transversum, Kupffer. In Ganoids, especially the sturgeons, it is voluminous, and as described above, in *Amia* it envelopes the epiphysis which thus appears suspended in it by a mesal fold. It does not seem to be a true evagination, such as the epiphysis and paraphysis, but a dorsal extension of the diacoele, due perhaps entirely to mechanical causes and given the

[1] The suggestion of Locy that the difference in size between the left and right habenas was due to this innervation, fails, since it it the right and not the left which is the larger, and whatever the cause of this, it is associated with a similar difference in the Meynert's bundles springing from them. This peculiar asymmetry in *Petromyzon* also exists in *Amia*.

[2] Synonymy; Zirbelpolster, Burckhardt; Parencephalon, Kupffer; Postparaphysis, Sorensen; Vesicle of the Thalamencephalon, Parker and Balfour; Recessus praepinealis, Leydig (?).

appearance of an evagination by the velum. The last structure has been recognized in Amphibia and Reptilia and appears of morphologic value. By some it has been assumed as the boundary between the prosencephal and diencephal. In *Amia* it passes ventrally immediately caudad of the cerebral lobes, which slope at their caudal end and hence give the dorsal sack more volume. The velum is attached to the recurved edge of of the cerebral lobes and therefore the same condition of the latter would render greater the extent of the velum. The prominence of the velum in Ganoids may be in part due to the recurved condition of the cerebral lobe at its caudal end.

The membranous roof caudad of this fold has a modification which when first observed was rather startling. There occurs on each side a lateral extension of the cavity just caudad of the velum, forming diverticula which divide into two limbs, caudal and cephalic. The latter extends cephalad just ventrad of the recurved edge of the cerebrum as far as the olfactory lobes (Figs. 3, 4). The caudal limb is even more extensive: closely applied to the side of the mesencephal, it reaches the cerebellum and the ventral portion passes farther caudad encountering the fifth nerve which divides it into a short dorsal portion and a longer ventral one, which in some brains at least attains the level of the ninth nerve, closely applied to the ventral aspect of the oblongata.

Lepidosteus resembles *Amia* closely. The relations are somewhat modified however by the different shape of the cerebral lobes. These do not slope away at their caudal ends which are more closely applied to the geminums and more nearly perpendicular to the dorsal surface. The recurvature of the dorsal edge is not so great (fig. 2). All this limits the capacity and extent of the dorsal sack and the size of the velum. The caudal extension of the dorsal sack upon the mesencephal is somewhat greater than in *Amia*. The epiphysis in *Lepidosteus* is in its proximal part enveloped in the dorsal sack and extends caudad to bend cephalad forming a V. In *Amia* the epiphysis first passes cephalad then caudad and again cephalad, performing thus a sigmoid curve. The lateral diverticu-

lum caudad of the velum exists, but the closer approximation of cerebrum and geminum renders it far less conspicuous. The slightly recurved lobes also do not form the interval occupied in *Amia* by the cephalic portion of the diverticulum, and this in *Lepidosteus* is flatter. The caudal portion is also extensive and reaches at least to the cerebellum, but here a complication existed which prevented the caudal limit being ascertained; namely, the presence of similar lateral extensions of the membranous roof of the metencephal. Some distance caudad of the metatela lateral pockets appear upon the sides of the oblongata (or myel) which farther cephalad are seen to be from the metaplexus. From the point where they join the metaplexus cephalad there is a lateral extension of the cavity, or rather more correctly, a series of lateral extensions which in some regions reach to the ventral surface of the brain and almost meet each other at the ventrimeson (Fig. 5). There is also a projection of the metatela over the surface of the cerebellum.

The membranous roof of the prosencephal, the mesal fold from it, the dorsal sack and velum and the metaplexus in *Amia* and *Lepidosteus* are lined with an endymal epithelium of large columnar cells which are of the appearance characteristic of secreting cells; the nucleus is situated in the base and the cell body stains but lightly, resembling some mucous cells. The lateral diverticula are also lined by such cells, but only on their ectal side; the ental side toward the brain, being very delicate and lined with flattened cells. The membranous roof of the fore-brain, the velum and mesal fold are all richly supplied with blood vessels, or blood spaces, and the ectal surface of the diverticula is also similarly supplied. We cannot doubt that the columnar cells of the membranous portions of the brain roof are of use in the elaboration of the coeliolymph. Vascular portions of the telas of the brain, generally appearing as plexuses, are of quite usual occurrence, and must have an important function in the nourishment of the organ. The only explanation of these diverticula that appeals to me is that they are for the increase of secreting surface. This may be accomplished in either of two ways, by reduplication, as in the forma-

tion of folds and villi in the alimentary tract and plexuses in the brain; or by expansion, and it seems to be the latter method adopted in the brain of *Amia*. In the formation of folds or plexuses it is necessary for the blood vessels to intrude into the brain cavity; here the cavity has, as it were, come out to the blood vessels. The same seems to be true of the metaplexus, of *Lepidosteus*, and it is interesting to note that, whereas in *Amia* the metaplexus is richly folded, in *Lepidosteus* it is entirely smooth save for small folds at the sides.

Careful examination of other Ganoids may reveal conditions much like those existing in these two. Both *Polyodon* and *Acipenser* brains are covered with a dense layer of connective tissue which may involve such outgrowths of the diatela as here described. Studnicka has recently reported that in *Polypterus* the dorsal sack extends caudad as far as the cerebellum and the description and figures of Waldschmidt suggest strongly even an exaggeration of the conditions in *Amia*.

Paraphysis.—The presence of the paraphysis in *Amia* has already been noted by Hill. In the adult it opens into the cavity just cephalad of the velum (Fig. 4) and possesses many tubular diverticula which occupy space in the velum (Fig. 3), in the membranous roof of the prosencephal and in the caudal part of the mesal fold. These are lined with a cubical or columnar epithelium which, it is important to note, is of a different appearance and easily distinguishable from the cells of the dorsal sack and membranous roof. The paraphysis does not seem to be a sack caused by or of the same nature as a plexus; on the other hand, neither is it an evagination of the same appearance and significance as the epiphysis and the view of His, Kupffer, and Leydig ('96), that it really is an epiphysis, does not seem correct; the terms employed by them, vordere Epiphysis and Epiphysis I, should not be confused with the anterior epiphysis or epiphysis I used by others and in this article. The paraphysis seems a structure in itself. The cells have indeed the appearance of secreting cells, but of a nature different from those of the surrounding epithelium.

The paraphysis also exists in *Lepidosteus*, appearing much

as in *Amia*. *Acipenser* (Kupffer, Epiphysis I) and *Polyodon* (Studnicka, '96) both possess it as doubtless do other Ganoids.

In cephalo-caudal succession we find then, on the mesal section of this region of the brain of *Amia*, the mesal fold of the prosotela, the paraphysis, the velum, the dorsal sack enveloping epiphyses I and II, the supracommissure and then the epiphysis (II).

SUMMARY.

1. Epiphysis I (anterior epiphysial vesicle) persists in adult *Amia* and has a strong fiber connection with the left habena.

2. The cavity caudad of the velum possesses in *Amia* and *Lepidosteus* lateral extensions which extend cephalad and caudad for a considerable distance.

3. The paraphysis is present in *Amia* and *Lepidosteus* and seems a distinct structure.

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DESCRIPTION OF FIGURES.

ABBREVIATIONS.

ch.—chiasma.
s. d.—dorsal sack.
d. l.—lateral diverticula.
epi.—epiphysis (epiphysis II.)
epi. I.—cephalic epiphysial vesicle (epiphysis I.)
hb.—habena.
hy.—hypophysis.
mtp.—metaplexus.
par.—paraphysis.
vel.—velum transversum.
II.—optic nerve.

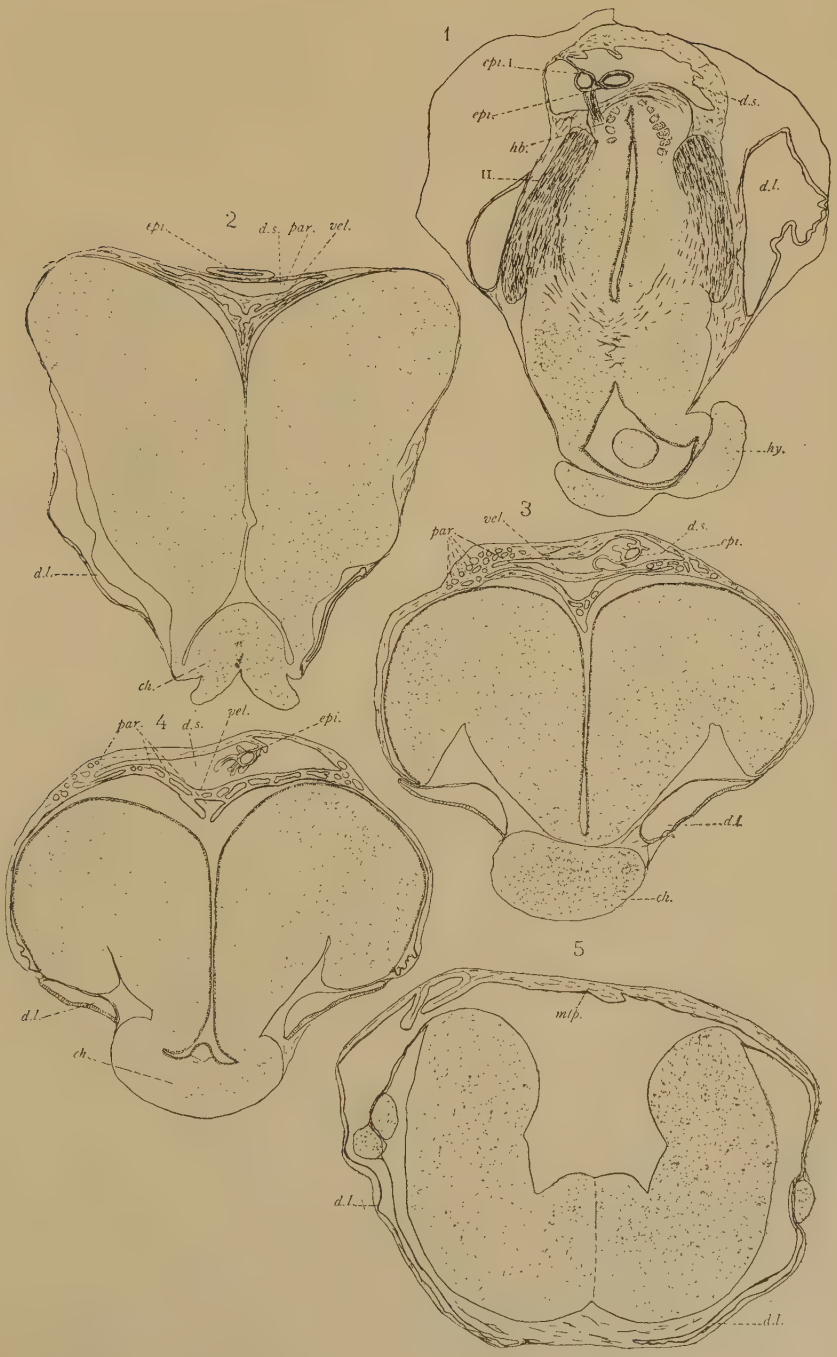
Fig. 1. Transection of the Brain of *Amia* at the level of the cephalic epiphysial vesicle, showing its fiber connection with the left habena, and the lateral diverticula. The cephalic tips of the optic lobes and the connective tissue adjoining, which occupy space enclosed by the outer line are omitted to simplify the figure.

Fig. 2. Transection of the prosencephal of *Lepidosteus*, to show the epiphysis (II), dorsal sack, paraphysis, and the lateral diverticula of the cavity.

Fig. 3. Transection through the prosencephal of *Amia*, showing the epiphysis, dorsal sack, paraphysis and cephalic extensions of the diverticula.

Fig. 4. Transection of the brain of *Amia*, showing the same general features as figure 3, but farther caudad, at the level of the opening of the paraphysis.

Fig. 5. Transection of the metencephal of *Lepidosteus*, showing the lateral extension of the cavity beneath the metaplexus.


1
epi.1.
epi.
hb.
II.
d.s.
d.l.
hy.
2
epi.
d.s.
par.
vel.
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ch.
3
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vel.
d.s.
epi.
d.l.
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4
par.
d.s.
vel.
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5
mlp.
d.l.
d.l.

THE DEMONSTRATION OF KARYOKINESIS.

By B. F. Kingsbury.

From the Journal of Applied Microscopy, May, 1898.
Vol. I, No. 5. Pp. 80-83.

Recent inquiries, one of them from an American medical college, seeking information as to methods of demonstrating the indirect division of cells, or karyokinesis, suggest that there may be others to whom as teachers or private workers a few hints as to material and methods will be helpful. Indeed, the writer's personal experience permits him to appreciate the help that may be afforded by such suggestions as are here intended. There certainly appears to be a lack of any specific suggestions or directions, those being most satisfactory that are contained in Whitman's* Methods of Microscopical Anatomy and Von Kahlden's† Pathological Histology, in neither of which is there suitable information as to material.

Nothing original is offered save perhaps a few observations on favorable forms for American workers, the intention being simply to present clearly a few standard methods in use here and elsewhere by means of which preparations may be obtained that will fulfil most of the desiderata in the demonstration of karyokinensis, *i. e.*, the occurrence of all the stages in the same preparation, showing well the chromatic and achromatic figures in cells of a size well suited for class demonstration.

Since Schneider, in 1873, first established the occurrence in cell division of the intricate phenomena constituting what is variously termed karyokinesis, mitosis, or indirect cell (nuclear) division, we have had demonstration of it in all groups of animals, from the protozoa to man, and in plants from the algae to the higher phanerogams, and the earlier conceived direct division of cells has been found to be of rarer occurrence. For demonstration, however, attention was soon confined to nar-

* Whitman, C. O. Methods of Research in Microscopical Anatomy and Embryology. Boston, 1885.

† Kahlden, C. von. Methods of Pathological Histology. Translated by H. M. Fletcher. London, 1894.

rower limits and a choice is given of Amphibia and the eggs of Ascaris megalocephalia, the parasitic round worm of the horse, and of the Echinodermata (sea-urchins, etc.) Among plants, the young embryo-sack of Fritillaria and the developing pollen cells of the members of the Liliaceae appear to have been favorite objects for demonstration, It is interesting to observe how closely anatomies published after 1885 confine themselves to these three groups for illustration of cell-division, with other forms, of course, occasionally supplementing or supplanting.

The Amphibia are by far the favorites, both because of the large size of the cells, their availability, and the pioneer work done upon them by Flemming* and Rabl,† whose figures are often copied. Both the larval and adult animals may be used. Karyokinesis, however, is best shown in special localities; in the adult the testis, corneal epithelium, and epithelium of the tongue; in the larva the epidermis, oral and branchial epithelium. The epithelium of the lung and peritoneal cavity have also been employed. It is to be noted that the forms on which work has been done, and to which references in the literature apply, are almost exclusively European, Salamander and Triton, and some may not realize the availability in America of forms fully as serviceable as either of these.

Of the organs above mentioned, the testis seems on some accounts most to be preferred, the only objection being that the results are dependent on the breeding habits of the animal, and therefore on the time of year. Salamandra, the European form so much worked on, mates early in the spring, and, as Flemming‡ first made known, spermato-genesis occurs as a yearly cycle beginning with the breeding season. After the deposition of the spermatozoa, there is a general increase in the size of the testis during the spring months, caused by a multiplication of the residual cells (spermatogonia). This is most vigorous during the late spring and early summer, May to July. In July and the first part of August the final divisions take place and the maturation of the zoösperms begins, extending well into the fall. The winter is spent with the testis in a resting state, charged with ripe spermatozoa. Thus in order to obtain karyokinesis, it is necessary to use animals taken during the late spring or early summer.

In America, we are favored with a larger number of forms with a greater range of habits, allowing us to be somewhat more independent of the time of year. Diemyctylus (viridescens, represented on the Pacific slope by torosus), the vermillion-spotted newt, in its range and the ease with which it may be obtained from ponds and ditches in the eastern United States, is perhaps most available of our forms; it is, however, quite nearly related to the European salamanders and resembles them closely

* Flemming, W. Zellsubstanz, Kern und Zelltheilung. Leipzig, 1882.

† Rabl, C. Ueber Zelltheilung. Morph. Jahrbuch, Vol. X, 1884-85; pp. 214-330.

‡ Flemming, W. Neue Beitrage zur Kenntniss der Relle. Arch f. mikr. Anat., Vol. XXXIX, 1887, p. 389.

in its mating habits and spermatogenesis, making it available for the demonstration of cell-division only during the late spring and summer months. Karyokinesis may be found well into August, though not abundantly. The males are easily distinguished by the greater size of the hind legs and the broad caudal fin-fold. The portion of the testis containing cells is a translucent gray, while that in which the lobules are filled with ripe spermatozoa is an opaque white or yellow white, as Flemming pointed out in Salamandra, there being in neither form pigment to obscure the effect.

Amblystoma (punctatum in the East, tigrinum in the central portions) also mates in the early spring (March or April), and presumably in the stages of spermatogenesis it corresponds in general to Diemyctylus. Cell-multiplication is still going on in early August, however. Amblystoma is not as easily obtained as Diemyctylus, secluding itself under logs and stones except at the breeding season, when it is valueless for karyokinetic purposes.

Necturus (the mud-puppy or water-dog of the vernacular) presumably must likewise be taken in the early summer, since individuals taken from early fall to late winter show the testis filled with ripe spermatozoa. It has been difficult to obtain it here during late spring or early summer.

In addition to these salamanders, which are available, and contrasting with them, we have as occupants of the brooks in the eastern United States, two other genera of salamanders, Desmognathus, the dusky salamander, and Spelerpes. Little is known of the breeding habits of these genera, but all evidence that we have points to the fact that the breeding season, instead of coming in early spring, comes in late summer or even late in the fall, eggs having been found in October.* At all events, lobules in stages of karyokinesis are found in specimens taken in early fall to midwinter, and probably, in the case of Desmognathus at least, up to April. In both of these the testis are densely pigmented and the regions of cells and spermatozoa cannot be as easily distinguished as in Salamandra or Diemyctylus. Spermatogenesis, however, seems to proceed from the cephalic toward the caudal end, causing an enlargement of the testis and a diminution of the amount of pigment, and it is in the narrower region, or where the larger and smaller portions meet, that cell-division is generally found. In Desmognathus, there are sometimes (not always) found two, rarely three, divisions of the testis, corresponding apparently to two centers of spermatozoa formation.

Testes of Diemyctylus and Amblystoma, then, are suitable for karyokinesis during spring and early summer (May, June, July); Desmognathus and Spelerpes, on the other hand, may be employed during fall and

* Sherwood, W. L. The Salamanders found in the vicinity of New York City, with notes on extra-limital or allied species. Proc. Linnaean Soc. of N. Y., No. 7, 1895; pp. 21-37.

winter. Doubtless other genera belonging to the same families will likewise be found equally serviceable at the same seasons.

The fixing fluids that experience has shown to be most suitable are: Hermann's platino-aceto-osmic, (Formula: Platinum bichlorid ten per cent. aq. sol. three parts, one per cent. osmic acid sol. sixteen parts, glacial acetic acid two parts, water nineteen parts; or, take platinum bichloride one per cent. sol. fifteen parts, two per cent. osmic acid four parts, glacial acetic acid one part); Flemming's chromo-aceto-osmic mixture (strong formula) is the same as Hermann's, save that chromic acid is substituted for the platinum bichloride), and also picric acid. The method of their use is as follows: It will be found best to cut the testis through the middle of the enlarged portion. Place both pieces for twenty-four hours in an abundance (15-20 cc. per testis) of either Hermann's or Flemming's fluid; wash in running water six hours or over night, and harden in alcohols of fifty, seventy and eighty-two per cent. strengths. The superficial layers of cells will be found to be over-fixed and detail partly or entirely lost; deeper cells will, however, be satisfactory. A thorough washing out of the fixer is important, that there be no subsequent blackening of or precipitate in the tissue. Sometimes, nevertheless, a precipitate occurs which may be removed by bleaching for a few minutes before staining, with a mixture of one cc. of hydrogen dioxide solution in ten or twenty cc. of seventy per cent. alcohol. Paraffine should be employed for imbedding; the sections should be between five and ten μ in thickness and be made longitudinally of the testis. For staining, most serviceable will be found Heldenhain's Iron Hematoxylin with or without after-staining in orange G, or safranin with or without light green as a counter-stain. For the iron hematoxylin (a) mordant for one hour in a four per cent. aq. sol. of ferric alum (iron-ammonium-persulphate), rinse well in water one or two minutes, (b) stain one to three hours or until black in a four-tenths per cent. aq. hematoxylin (may be conveniently made up by taking three cc. of a sixteen per cent. alcoholic stock solution of hematoxylin in one hundred cc. of water.) Any aqueous hematoxylin may be taken, however, the time of staining being longer for weak formulas. (c) Rinse in water and differentiate by dipping into the ferric-alum solution for a few seconds and then rinsing in tap water, repeating the operation until the right degree of differentiation is attained as determined by examination under the microscope. The chromatin should be stained a blue-black or black, the spindle gray or light blue. Wash well in water for about twenty minutes and dehydrate, clear and mount in balsam, or, if it is preferred, stain after washing for a minute or so in a strong one-half saturated aqueous solution of orange G.

One of the best safranin stains to employ is Babes'—equal parts of concentrated aqueous and alcoholic solutions. Stain in this three to twenty-four hours, wash with ninety-five per cent. alcohol, clear, and mount in balsam. No other differentiation than that of the ninety-five per cent. alcohol is needed with this formula.

Picro-acetic mixture, of which there are several formulas, is possibly even better than the two standard fixers just mentioned. It is a saturated aqueous solution of picric acid, or (possibly better) a half saturated solution (saturated solution one part, water one part) of picric acid with one or two per cent. of glacial acetic acid added. Place the testis in this for six to twelve hours, soak in seventy per cent. alcohol one day and in eighty-two per cent. alcohol several days, changing until the picric acid is almost entirely removed, when it may be carried on for imbedding. The most satisfactory stain with tissue fixed in this way is Heidenhain's iron hematoxylin, as above. The time of mordanting and staining may be much shorter than with Hermann's or Flemming's ; one-half hour in the ferric alum, and half an hour in the stain. Safranin is as not satisfactory with this fixer as with Flemming's or Hermann's. Any one of these fixers and stains gives good figures of cell-division, suitable for demonstration.

The testis of the crayfish, so common in our rivers and streams, likewise is a very good subject for the demonstration of karyokinesis, the only objections being the small size of the cells and the large number of chromosomes. Their division, however, is very easily demonstrated, as is also the centrosome. The testis will be found immediately beneath the heart, on the dorsal side, under the carapace, and is easily distinguished as a three-lobed white organ. It may be removed from a five to eight cm. male in the summer or fall and fixed and stained in one of the ways mentioned above. The sections should not be more than five or seven μ thick.

The larvae of Amphibia, especially the tailed forms, are very suitable objects for the demonstration of cell-division. Just hatched specimens are most suitable, although rapidly growing forms, such as Amblystoma should be suitable throughout the spring. While division figures may be found readily in all parts of the body, the epidermis and oral epithelium are the most favorable regions. By fixing but a short time (one to two minutes) it is possible to remove large pieces of the epidermis by scraping, and these may be washed, examined, stained if found suitable, and mounted without further treatment. It will be found more satisfactory, however, to fix the caudal portion in one-third per cent. platinum chloride or chromo-formic (four or five drops of strong formic acid in two hundred cc. of a one-third per cent. aq. solution of chromic acid, added just before using). Leave in either of these twenty-four hours, wash in water four to six hours, and harden in fifty, seventy and eighty-two per cent. alcohols. Sections parallel to the surface should be made so as to cut the epidermis very obliquely and have more cells iu each section. Amblystoma is most favorable, since the young larvae are not densely pigmented and grow very rapidly. Spelerpes larvae, although they may be found during summer and winter, are not serviceable, apparently because of their slow growth.

The Amphibia have one disadvantage, in that the achromatic portion of the figure is not as strongly developed as is desirable ; the testis seems the least objectionable from this aspect. On the other hand, in invertebrate eggs generally, and especially Ascaris and Echinoderm eggs as most available, the spindle and polar radiations are strongly developed. These forms are not as generally available as are the Amphibia. Those who are so located that they have access to freshly killed horses may obtain from the coecum or ileum, the parasitic worm, Ascaris megalocephala, from which the uteris filled with developing eggs may be removed and fixed in either of the three following fluids : (a) Glacial acetic acid one part, absolute or ninety-five per cent. alcohol three parts : (b) absolute alcohol one part, glacial acetic acid one part, chloroform one part, and mercuric chloride to saturation ; or (c) seventy per cent. alcohol eight parts, glacial acetic acid two parts, which formula Professor Conklin of the University of Pennsylvania has stated to be very satisfactory. In formula (a), wash out with strong alcohol until all odor of acetic acid has disappeared ; in formula (b), wash thoroughly in fifty per cent. alcohol until all trace of the acid has been removed, and in seventy and eighty-two per cent. alcohols changing until the mercuric chloride has been all washed out ; in formula (c) wash one day in seventy per cent. alcohol and store in eighty-two per cent. alcohol.

Mammals from which demonstrations of karyokinesis are most to be desired, especially for medical students, are, nevertheless, the most unsatisfactory. The testis again, especially of rodents such as the mouse, rat, or guinea-pig, is perhaps most favorable. It should be cut up into small pieces and fixed in Flemming's or Hermann's twenty-four hours, washed in running water several hours, and hardened in the alcohols. Iron Hematoxylin or safranin will again be found the most satisfactory stain. The mesentery of new-born rabbits has been recommended as affording sasisfactory demonstrations of cell-division in the covering epithelium.

Likewise the amnion of the rat has been advanced † as a good tissue for demonstrating indirect cell-division. White rats were employed and the amnion of embryos, eighteen to twenty mm., were fixed in strong aqueous solution of picric acid (picric-acetic will do) or Flemming's fluid, spread out flat on the slide, and stained with hematoxylin. The karyokinetic figures are represented as being numerous and large. Neither of these methods have been personally tested ; it is suggested that other new-born animals, e. g., kittens and the amnion of other embryos, may be used with equally good results.

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* Orth, Joh. Cursus der normalen Histologie zur Einfuhrung in den Gebrauch des Mikroskopes sowie in das praktische Studium der Gewebelehre. 5te Auff. Berlin, 1888.

† Solger, B. Saugethier-Mitosen im histologischen Kursus. Arch. f. mikr. Anat., Vol. XXXIII, 1889, p. 517.

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ARTICLES.

Preparation of Culture Media with Special Reference to Sterilization. American Monthly Microscopical Journal, Vol. xviii, No. 5, May, 1897. Pp. 149–154.

Dahlia as a Stain for Bacteria in Sections cut by the Collodion Method. Transactions of the American Microscopical Society. Vol. xix, 1897. Pp. 182–185.

Preparation of Culture Media with Special Reference to Sterilization.

By Raymond C. Reed, Ph. B.

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The amount of culture media used by the students in a bacteriological laboratory is so great that its preparation after the method given in the text books occupies an undue proportion of the time allotted to this subject. If it is prepared by an assistant and furnished to the students it not only takes much of his time, but it deprives the student of the opportunity of learning one of the most important processes necessary for successful work in bacteriology. Hence any change which will shorten the time required for its preparation will be of value. When it is prepared by the usual method recommended in text books on Bacteriology at least three days are necessary to complete the process of sterilization. The method of sterilizing by which the media is heated to a somewhat higher temperature than 100° C. by means of superheated steam is open to the objection that the nutritive properties are impaired to a greater or less extent for certain species of bacteria.

In 1890 Moore* published a paper giving the method employed in the Bureau of Animal Industry for making nutritive agar and which seems to be the one recommended, with slight variations as to details, in the greater number of bacteriologies. The two most important changes suggested were, (1) that when the agar was made from meat infusion instead of meat extract, it should be prepared from bouillon which could be made up in quantities and kept stored in flasks as stock ready for use. This applies not only to the making of agar but also gelatin

*The Preparation of Nutritive Agar. By V. A. Moore, M. D., American Microscopical Journal, May, 1890.

or any other medium which requires a meat infusion for its nutritive base. (2) That the agar should be cut up in small pieces and dissolved in a liquid which contains no coagulable material before it is added to the bouillon. This is done by using the proportion of five grams of agar, finely chopped, to 100 c. c. of water and boiling in an agate iron dish over a direct flame with constant stirring. I have found, however, that it is more satisfactory to boil the agar in a closed water bath. This takes not to exceed twenty minutes longer and as there is no danger of the agar burning the stirring and constant attention required when it is dissolved over a flame is unnecessary. By this method the agar is completely dissolved and a medium of a known consistency can always be made.

In 1892 Schultz,* of the Johns Hopkins Hospital, described a rapid method of making agar which requires but one hour for the whole process. For this he uses meat extract which gives a medium favorable for the growth of some organisms but not for others. He also gives a method by which the agar may be made from meat infusion taking but an hour and a half.

The following method of preparing media has proved very satisfactory and in my hands more so than the one described by Schultz although his process has many advantages.

The preparation of peptonized bouillon.—To 1000 grams of finely chopped or ground meat (beef or veal) add 2000 c. c. of distilled water. Put in an agate iron dish and heat in a water bath at a temperature of from 60° to 65° C for two hours or allow it to macerate in a cool place for 24 hours. Strain through a coarse cloth and bring the amount of liquid up to 2000 c. c. by adding water if necessary. To this infusion add ½ per cent peptone and

*A Rapid Method of Making Agar-agar. By John L. Schultz. John's Hopkins Hospital Bulletin, No. 24, July—Aug., 1892.

½ per cent sodium chloride and if a neutral or alkaline medium is desired add enough of a 1 per cent solution of caustic soda to bring about the required reaction. Boil in a water bath for half an hour. Cool and filter through ordinary filter paper and distribute in sterilized flasks. The amount in each flask is to be determined by the work in the laboratory. I have found 500 c. c. a convenient quantity.

Preparation of nutrient agar.—Dissolve 5 grams of finely cut agar in about 100 c. c. of water. This may be done in either of two ways, by heating over a direct flame for about ten minutes with constant stirring to prevent burning or by heating in a closed water bath until the whole mass becomes gelatinous. The agar is then added to 500 c. c. of bouillon, thoroughly mixed with it and boiled in a water bath for twenty minutes. It is then cooled down to 45° to 50° C. and the whites of two eggs added and thoroughly mixed with the agar. It is then returned to the water bath and boiled for from twenty to thirty minutes. The albumen will then be collected in a firm coagulum containing any insoluble particles that may have been in the agar, leaving a perfectly clear liquid. It is filtered while hot through ordinary filter paper, the filtration taking place rapidly without the aid of a hot filtering apparatus. The filtrate is then distributed in tubes which have been previously plugged with absorbent cotton and sterilized.

Preparation of nutrient gelatin—To 500 c. c. of bouillon add 50 grams of gelatin and heat in a water bath until the gelatin is dissolved. Cool to about 45° C. and and the whites of two eggs, mix thoroughly. This is done most rapidly and effectually by pouring the liquid several times from one dish to another. Then boil in a water bath for twenty minutes. Filter through ordinary filter paper and distribute in sterilized tubes. Care

must be taken not to boil gelatin too long or it will lose its property of solidifying when cold.

Sterilization of Media. It will be seen that the process of preparing culture media up to the point of sterilization is practically the same as that described in recent text books on bacteriology. The method is short and by having the nutritive medium prepared and kept in stock the preparation up to this point of either agar or gelatin is very simple. The essential time consuming part of the process is the sterilization. Although this has now been reduced from the boiling on six consecutive days to three, it is still an important element in laboratory work especially where students are present but two or three days, usually alternating, in each week.

During the past two terms I have made a considerable number of experiments for the purpose of determining if it is necessary in order to secure complete sterilization to boil media, when distributed in small quantities in tubes, for three consecutive days. In these experiments I have found that one boiling for a slightly longer time, thirty minutes, seems to be all that is necessary to sterilize bouillon, nutrient agar and nutrient gelatin distributed in either small or large tubes. After distributing the medium the tubes were put in a closed water bath and boiled vigorously for thirty minutes. At the expiration of that time they were taken out and placed in an incubator where they were allowed to remain for several days, when it was a simple matter to sort out and reject any tubes that may have been contaminated. As will be seen from the appended tables, giving the results of these experiments, contaminations have been very rare. In fact they have not been much if any more numerous than they were when the three regular boilings were employed. Although several of the agar and gelatin tubes were not sterilized, they were contaminated with a spore

bearing bacillus which has not infrequently appeared in media boiled for ten minutes on three consecutive days.

STERILIZATION OF BOUILLON WITH ONE BOILING.

Date.	Number of tubes.	Amount in each tube.	Time boiled.	Days in incubator after boiling.	No. of tubes contaminated	Remarks
Jan. 9, 1897	40	7 c. c.....	30 min.....	7	0	.....
Jan. 14, 1897	80	7 c. c.	30 min.....	7	0	.....
Jan. 14, 1897	14	25 c. c	30 min.....	7	0	Fermentation tubes with one per cent. glucose.
Feb. 5, 1897	32	7 c. c.....	30 min.....	7	0	.....
Feb. 11, 1897	35	7 c. c	30 min.....	6	0	.....
Mar. 5, 1897	46	7 c c	30 min.....	7	0	.....
Apr. 6, 1897	45	7 c. c	30 min.....	5	0	.....

STERILIZATION OF AGAR WITH ONE BOILING.

Date.	Number of tubes.	Amount in each tube.	Time boiled.	Days in incubator after boiling.	No of tubes contaminated.	Remarks.
Jan. 22, 1897	50	7 c. c	30 min.....	7	3	Each of the three tubes contained a spore bearing bacillus belonging to the *B. subtilis* group.
Jan. 27, 1897	48	7 c. c	30 min.....	7	2	Same as above.
Feb. 5, 1897	81	7 c. c.....	30 min.....	6	0	.....
Feb 13, 1897	14	7 c. c.....	30 min.....	7	0	.....
Mar. 16, 1897	25	7 c. c.....	30 min.....	7	0	.....
Mar. 27, 1897	41	7 c c.....	30 min.....	7	0	.....
Apr. 6, 1897	40	7 c. c.....	30 min.....	7	0	.....

STERILIZATION OF TUBES OF AGAR CONTAINING A LARGER QUANTITY FOR MAKING PLATE CULTURES.

Date.	Number of tubes.	Amount in each tube.	Time boiled.	Days in incubator after boiling.	No. of tubes contaminated.	Remarks.
Dec. 29, 1896	30	12 c. c.....	30 min.....		0	Left at room temp. for 10 days
Jan. 27, 1897	26	15 c. c.....	30 min.....	7	0	.....
Feb. 5, 1897	15	15 c. c.....	40 min.....	6	0	.....
Mar. 16, 1897	35	18 c. c.....	30 min.....	7	0	.....
Mar. 27, 1897	43	18 c. c.....	30 min.....	7	3	Spore bearing bacillus belonging to the *B. subtilis* group.
Apr. 6, 1897	40	18 c. c.....	30 min.....	7		.....

STERILIZATION OF GELATIN WITH ONE BOILING.

Date.	Number of tubes.	Amount in each tube.	Time boiled.	Days in incubator after boiling	No. of tubes contaminated.	Remarks.
Dec. 29, 1896	30	12 c. c.....	30 min....		0	Left at room temp for 14 days
Feb. 19, 1897	30	15 c. c.....	30 min....	7	0	.....
Mar. 18, 1897	15	18 c. c	30 min....	7	0	.....
Do.....	25	7 c. c.....	30 min....	7	1	Contained a spore bearing bacillus belonging to the *B. subtilis* group.
Mar. 23, 1897	10	18 c. c	30 min....	7	0	.....
Do.....	36	7 c. c.....	30 min....	7	0	.....
Mar. 25, 1897	35	7 c c	30 min....	7	0	.....

If spore bearing bacilli are present in large numbers more difficulties might be experienced. But ordinarily if the medium is prepared with proper care and distributed as soon as filtered, in sterile tubes and boiled at once very few contaminations are likely to occur.

The time that must elaspe before the medium can be safely used is not so much shorter than when the customary method is employed but the time actually spent in sterilizing is much shorter. In a crowded laboratory this is important. It probably is not necessary to leave the media in the incubator from five to seven days as I have indicated in the above tables for in every case of contamination the growth took place within the first twenty four hours.

I am not prepared to say that this method is the best or that it is safe for all kinds of work, but it has proved to be well adapted to the needs in a student laboratory and to save much valuable time for both the student and the teacher.

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DAHLIA AS A STAIN FOR BACTERIA IN SECTIONS CUT BY THE COLLODION METHOD.

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Many elaborate methods of staining bacteria in tissues have been devised, but with nearly all of them difficulties have been encountered. Probably the greatest trouble has been in the staining of the imbedding medium or the albumen fixative which usually obscure both the tissue elements and the bacteria. Unless, therefore, the sections are cut in paraffin and not fastened to the slide by these common fixatives the bacteria are not satisfactorily brought out. Here again arises another obstacle. With loose or fragile tissues there is great danger of tearing the sections or of losing parts of them during the process of staining and dehydrating, thus destroying the value of the preparation.

Although paraffin is commonly used in pathological histology, collodion is more often employed in imbedding normal tissues. The rule in normal histology is to fasten the sections to the slide. In pathological histology they are not, for the reasons mentioned, ordinarily fastened, but in many cases it seems better to do so. The need of having an absolutely perfect section from a pathological tissue, especially for diagnosis, is even greater than is the case when sections of normal tissues are being made. The loss of a very small bit from the section may cause an entirely erroneous interpretation. By the use of collodion as the imbedding medium this danger is practically entirely eliminated, while the method is much simpler and easier than that in which paraffin is used and the sections are fastened to the slide by the use of collodion or an albumen fixative.

It is a well known fact that collodion takes most of the aniline dyes and will not give up the stain without being treated with a decolorising agent sufficiently strong to decolorise the tissue at the same time. In the case of paraffin sections which have been fastened to the slide with collodion or albumen fixative, or both, besides the disadvantage of using a process which takes a longer time, we meet the same difficulty that we did in the collodion method, in that the fixative takes the stain and obscures the preparation quite as much as does the imbedding collodion.

Both the collodion and the paraffin methods have their advantages for special kinds of work. Ordinarily in pathological histology I much prefer, for the reasons mentioned, collodion to paraffin as an imbedding medium. The method I have used is that described by Prof. S. H. Gage* in a paper read before this society in 1895. In it he summarised the whole process of sectioning by the oil-collodion method and suggested two very important improvements in the way of simplifying and cheapening the process. This method includes the improvements suggested by Dr. P. A. Fish in 1893. Dr. Fish fastened the sections to the slide by putting a few drops of ether and alcohol on the section after it was in position. Prof. Gage used a mixture of three parts of xylene and one part of castor oil as a clarifier. In passing a section from water to strong alcohol, or vice versa, he avoids the diffusion currents by plunging the slide directly into the desired liquid instead of carrying it through successively higher or lower percentages of alcohol, as the case might be. This method, as perfected by Dr. Fish and Prof. Gage, is very simple and apparently the best one yet devised.

After finding the best method of cutting the sections the problem then seems to resolve itself into the selecting of a suitable dye that will stain the bacteria properly and yet one

* S. H. Gage, Improvements in Oil-Sectioning with Collodion. Proceedings American Microscopical Society, Vol. XVII., 1895, pp. 361–370.

† P. A. Fish, A new Clearer for Collodionised Objects. Proceedings American Microscopical Society, Vol. XV., 1893, pp. 68-89

that will wash out of the imbedding material without the use of a decolorising agent so strong that it will remove the stain from the tissue and the bacteria.

During the past year we have had a large amount of pathological material to section and for the most part for diagnosis. At first I cut most of this in paraffin, as Dr. Moore preferred it to collodion on account of the staining of the collodion. In the winter term I had some sections that I wanted to stain with gentian violet, but finding that we were out of it, I substituted dahlia in its place. These sections had been cut by the paraffin method and it was found that the stain not only showed the bacteria well but also brought out beautifully the histological structure of the tissue. Later I had occasion to cut some sections from some material which had been imbedded in collodion and to stain them for bacteria. After using other stains, such as carbol fuchsin and methyl violet, with unsatisfactory results, I tried an aqueous solution of the dahlia and found that it worked perfectly. In the process of washing and dehydrating this was entirely removed from the collodion, leaving both the tissues and the bacteria well stained and sharply differentiated.

Other formulæ, using dahlia as the dye, were tried, such as a solution containing less of the elements of a mordant nature, using 2 per cent. carbolic acid instead of 5 per cent., and also Koch-Ehrlich's aniline water solution. The carbolic acid solution did fairly well, but the aniline water solution stained the collodion too deeply and permanently. Neither brought out the cellular elements with anything like the clearness that the simple aqueous solution did.

The formula for the stain used is as follows :

Saturated alcoholic solution of dahlia	20 c.c.
Distilled water	100 c.c.

The length of time necessary to stain properly varies, according to the condition of the tissue, from fifteen minutes to half an hour, that is, they must be distinctly overstained.

Then wash thoroughly with 95 per cent. alcohol until the collodion around the section appears colorless, and clear with a clearing fluid, preferably clove oil. The tissue will be well defined and the bacteria will stand out deeply stained against the more lightly stained cells of the tissue.

Of course, this method will not do with certain bacteria that require special stains or treatment, but it does work most admirably with the majority of microörganisms found in diseased animal tissues.

RAY JONES STANCLIFT, D.V.M.,

Demonstrator of Anatomy.

ARTICLE.

Aseptic Castration of Male Animals.

American Veterinary Review, Vol. xxii, July, 1898. Pp. 249–272.

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ASEPTIC CASTRATION OF MALE ANIMALS.

GRADUATION THESIS BY R. J. STANCLIFT, STUDENT, NEW YORK STATE VETERINARY COLLEGE.

History.—The operation of castration is one that has been performed upon all domesticated animals and upon man for ten centuries B. C. (1.) The castration of man being first spoken of in the Bible in Isaiah, 56, 3; and ancient writers claim that the operation was in vogue before the time of Semiramis. (2.) Andramyties, the King of Lydia, is said to have sanctioned castration in both males and females of the human race for social reasons.

It is still practiced upon man in the Eastern countries that are of Mohammedan belief; also in China, and in some parts of India at the present time.

The castration of the female domesticated animals was known to the Danes in the sixteenth century, and they operated successfully upon sheep, swine, cows, and even mares. The bitch is spoken of as being operated upon about the first of the present century.

These operations are performed upon cattle and swine very extensively in the Western and Southern States, and upon the bitch throughout the whole country at the present time.

The emasculation of the male domestic animals is of double importance in the animal industry, as it renders the animal more gentle and docile and more obedient to his master's will, as in the gelding. It also increases the production of meat both in quantity and quality in animals, which are kept for that purpose, as we see in the emasculated bull, the steer, or in the case of the emasculated boar, the barrow. This is perhaps more forcibly illustrated in the emasculation of the cock, which increases his weight and produces flesh of a much superior quality. The operation has been found to give best results

in the meat-producing animals when performed at an early age.

Anatomy.—Before taking up the operation itself, it would be well to glance briefly at the anatomy of the seat of the operation.

In the normal animal, we have the testicles situated in the scrotum, between the thighs, in the horse and ruminants, while in the pig, they are situated more posteriorly and just below the perineum.

The scrotum is composed from without inwards of, first, the common integument, which is reflected from the thighs over the scrotum. This is thin and soft. It is covered with soft, downy hairs, and has a great number of sebaceous glands, the secretion from which keeps it soft and flexible. It is marked mesialy by a longitudinal raphe, which indicates a division into two portions, a right and left. Beneath the common integument, we have the dartos, a thin layer of muscular and elastic tissue, which is derived from the abdominal tunic and is continuous with it. This may be said to be the proper scrotal tunic, as besides covering the testicle, it sends a fold up between the testicles, called the septum scroti, corresponding to the outer longitudinal raphe. Beneath the dartos is the spermatic fascia, which is derived from the external oblique muscle. This is attached around the external abdominal ring and passes down over the cord and testicle. Inside this, is the cremasteric fascia, which is an expansion of the cremaster muscle. This arises from the iliac fascia and passes down the inguinal canal and spermatic cord to surround the testicle. This fascia forms only an incomplete covering, while still deeper is the infundibuliform fascia, which is an extension from the transversalis abdominalis muscle fascia. This is funnel-shaped and commences at the internal ring, passing down over the cord and testicle, and on the inside is continuous with the outer serous covering of the testicle.

Then we have the two peritoneal coverings, which are brought down by the testicle when it passes from the abdominal cavity to the scrotum. The outer one is spoken of as the

tunica vaginalis reflexa, and is united by cellular tissue to the infundibuliform fascia, on its outer surface.

The inner serous tunic, known as the tunica vaginalis propria, is attached on its inner side to the outer fibrous coat of the testicle; and the surface of these peritoneal coverings, which are in contact with each other, are lined with a single layer of squamous epithelium (endothelium) and thus forms a large lymph space, which is continuous with the peritoneal cavity, being, in fact, a portion of it, which was carried down with the testicle when it passed into the scrotum.

The testicle is the essential reproductive gland of the male. It is composed of an outer fibrous covering, from which trabeculæ extend inwards, dividing the gland up into pyramidal shaped spaces that contain the active secreting gland substance. It is surmounted on the superior border by the epididymis, which is the first portion of the excretory canal and which terminates in the vas deferens.

The testicle is suspended in the scrotum by the spermatic cord, which is composed of the vas deferens, posteriorly, and on the anterior border we have the great testicular or spermatic artery, which is very tortuous; and between these, we have a band of gray muscular fibres, and also the small testicular artery. These are all bound together by loose cellular tissue, which also contains nerves, lymphatics and the accompanying veins of the arteries. The spermatic cord extends from the testicle up to the external abdominal ring; inferior to this, it has the covering of the scrotum. It enters the inguinal canal and passes into the abdominal cavity, through the internal abdominal ring; here we will leave it, as for our purpose it is not necessary to trace it any further.

METHODS OF OPERATING WHICH ARE IN VOGUE AT THE PRESENT TIME.

The operation consists in the removal of the essential organs of generation, the testicles, or by bringing about a cessation of their functions. The methods used at the present time to bring this about can be divided into three classes.

The first class would include those operations, by which the envelopes of the testicle are cut through and the organ removed by section of the spermatic cord. This would include simple section of the cord with a sharp knife, which is claimed to be one of the oldest methods, and is still used upon some of the smaller animals. With larger animals, there is danger of profuse hæmorrhage.

Scraping is but a modification of the preceding operation, and consists in using a dull instrument to scrape the cord slowly through. This, by lacerating the walls of the artery hastens clot formation but is sometimes followed by severe hæmorrhage.

Torsion of the cord :—This is brought about after the envelopes have been cut through by grasping the cord at the point where it emerges from the incision, with forceps or the hand, and fixing it firmly; then with forceps or the hand grasping the cord just above the testicle, and by twisting to rupture the cord between these two points. This, by twisting and lacerating the fibrous coat of the arteries, occludes them and checks the hæmorrhage.

Crushing of the cord :—This is very common at the present day, and is accomplished by the use of the ecraseur, or by the emasculator, an instrument which has attained great popularity in the last decade; and, last, section of the cord by actual cautery. This is accomplished by applying a broad wooden clamp upon the cord up as close as possible to the scrotum and then applying a dull red hot cautery to the cord and severing it with this. The stump of the cord is cauterized until it is carbonized, and as soon as this is accomplished is released from the clamp.

The second class is but a modification of the first. Here the envelopes are incised the same as in the first, only there are applied certain means of pressure to the cord which are allowed to remain on. These are applied before amputation of the testicle, and consists of two methods—the application of clamps or of a ligature. The method of applying clamps is a very ancient

mode of operating. It is performed in two ways—the covered and the uncovered.

In the uncovered operation, the envelopes of the testicle are incised and the testicle removed from the envelopes. The clamps are applied to the cord above the epididymis and secured; then, the testicle and the remainder of the cord below the clamp amputated with a sharp scalpel. The clamps are usually made of wood and are two semicylindrical pieces joined together with strong cord. The surfaces that come in apposition usually have a longitudinal groove, which helps to prevent slipping, and by some operators this is filled with caustic paste. The clamps are usually allowed to remain on from thirty-six to sixty hours.

The covered operation.—In this, the envelopes are incised down to the cremasteric fascia. This is carefully dissected away from the outer envelopes and then the clamps are applied over the remaining unopened envelopes and the cord and secured here; then the testicle and surrounding envelopes are excised.

By ligation.—This is done by applying a ligature over the cord, after exposing the testicle by ligating the spermatic artery or by ligating over the inner envelopes after separating them from the outer, the same as for the covered operation, with the clamps.

In all these cases, the amputation is below the ligature.

In ruminants, which have a long pendulous scrotum, some operators have ligated the entire scrotum and allowed it to slough off. In these cases, an elastic ligature is preferable.

The third class would include those modes of operating where the scrotum is not incised, or a portion of it destroyed by the operation. These consist in either crushing the spermatic cord or operating by double subcutaneous torsion.

Crushing the cord is only practicable in the pendulous scrotum of the ruminant. The cord enclosed in the scrotum is placed between two straight sticks, which have squared edges,

and these are struck until the cord is crushed sufficiently to cause atrophy of the testicle to follow.

The double subcutaneous torsion of the testicle is produced by so manipulating the testicle in the scrotum as to produce a twisting of the spermatic cord and thus cause an interference with the blood supply of the testicle and atrophy from innutrition. This operation is also only applicable in ruminants, on account of its requiring a pendulous scrotum. Both are used in southern France, but are not in general use, as they are not always certain in producing the desired effect, besides having the disadvantage of the persistent atrophied testicle in the scrotum, which might be objectionable. For these reasons, the third class will not be considered any further.

The first two classes leave the scrotum open after the removal of the testicle. We find our veterinary writers mentioning swelling, (3) secondary hæmorrhage and suppuration (1) as the normal results of these methods of castration; also of peritonitis, abscess of scrotum, tetanus, champignon or schirrous cord, gangrene of the scrotum and glanders (4) as the abnormal sequelæ. All of these results, except the swelling, which may be an œdematous condition of the scrotum without infection, and the secondary hæmorrhage may be traced directly to bacterial infection; for tetanus has been proved to be due to a specific micro-organism, the bacillus tetani, as also has glanders to the B. mallei. Champignon or schirrous cord, or fistula of the scrotum, has been found to be due to infection with botryomyces (5), though it has not been proven that all of these cases are due to infection with this specific micro-organism.

The other sequelæ may be produced by a number of the pathogenic bacteria, which are pus producers, or are capable of producing septicæmia; bacterial infection is the danger to be feared in the operation and it is only to this that the bad results and fatalities can be traced. If we can carry on the operation without this infection, we have removed this danger, be it much or little.

The question arises, how can we prevent this infection? The majority of the veterinarians of the present day try to perform the operation under more or less complete antiseptic precautions, but after the operation is completed, even provided there has been no infection during this time, the wound is left open, and in all the methods, except the covered operation, there is a direct opening into the peritoneal cavity. Even in the covered operation, there is left the open scrotal wound.

These wounds always become infected to a greater or lesser degree, but those where there is an opening into the peritoneal cavity are the more dangerous. If, as in the majority of cases, the infection is slight, we have a correspondingly slight discharge of whitish creamy inoffensive pus, which some writers have called laudable pus, but which with our present knowledge of bacteriology cannot be recognized as such, for, clinically, we do not get pus formation without infection, and certainly infection is not laudable.

In these cases, there is usually healing by the granulation process, while if we get a virulent infection, we have what has been called the abnormal results of castration, as peritonitis, abscess of the scrotum, gangrene; or, if the infection is due to specific micro-organisms, tetanus, glanders or champignon, and the correspondingly bad results.

With the necessary environment of our domesticated animals, it is impossible by these methods of procedure to have practical antisepsis, which is necessary to have healing by primary adhesion. By obtaining healing by primary intention we do away with those sequelæ which are due to infection and thus lessen the danger of the operation.

In considering how we are to prevent infection, we must first determine how and where the infection can come from. This can all be summed up in three ways:

First, the infecting material may be upon the seat of the operation.

Second, it may be brought to the wound by the operator or his assistants.

Third, it may gain entrance after the operation has been performed.

These can be best considered in the order as given.

First, to prevent infection from seat of operation. Here, upon the skin, we have a great variety of micro-organisms, and these may consist of those which live upon the epidermis, and those obtained from the litter or earth. The latter are the more dangerous, as in these we may have the bacillus tetani or the bacillus of malignant œdema.

The seat of the operation should be cleaned thoroughly with soap and water and then disinfected afterwards with some good antiseptic, which can be washed off with distilled or boiled water, at the time of the operation.

Second, infection by operator or assistant. Here the infecting agents may be brought by the instruments used or by the hands or clothes of the operator. To prevent this, the operator's hands and clothes should be perfectly clean and the hands disinfected, the instruments sterilized, preferably by boiling or by a good antiseptic, and nothing allowed to touch the wound but what has been disinfected.

Third, the infection of the wound after the operation. In our domestic animals, we cannot apply any bandages or dressings to the scrotum, which can be kept in place, and thus obtain healing by primary adhesion, and if the wound is left open it is certain to become infected, so the only recourse is to close the wound by sutures and apply antiseptics to the parts until healing occurs.

The Aseptic Operation.—With a view of obtaining these results, a series of operations were carried out under antiseptic precautions at the clinic of this college. The general method of proceeding was as follows:

The animal was kept in the general ward one day in order to prepare it for the operation, and was fed a restricted laxative diet. The body of the animal was thoroughly cleansed and the sheath and scrotum well washed with soap and water.

At the time of operating, the patient was taken to the oper-

ating room, placed upon the operating table and chloroform administered. While this was being done, the scrotum and sheath were washed thoroughly with soap and water, after which the parts were wet well with sublimate solution, 1–1000; also the inner surfaces of the legs were moistened with this solution. As soon as the patient was anæsthetized the upper hind leg was drawn upward and forward out of the operator's way.

The instruments to be used were sterilized by being boiled for ten minutes in water, to which was added sufficient sodium bicarbonate to prevent oxidization of the instruments. The operator's hands were thoroughly cleansed with soap and water, great care being taken to clean the finger-nails, afterwards washing the hands in sublimate solution, 1–1000. The sublimate solution was then washed off the scrotum with boiled water; the upper testicle grasped by the operator's hand and an incision made through the scrotum at its most dependent part, parallel to the longitudinal raphe and from one to two inches on either side of it. This incision was just large enough to allow the testicle to slip out endwise.

The testicle was grasped by the hand and gently drawn well out. In cases I, II and III this was held by an assistant; but in the others, was fixed with a clamp.

A half-curved needle, threaded with sterilized catgut, was passed through the middle of the cord, where it emerged from the incision, or where it was held by the clamp as close to the instrument as possible. The anterior part of the cord was ligated, and without cutting the ligature, the whole of the cord was included in it; the cord severed below with the emasculator; the proximal end released from the clamp and any blood present washed off with boiled water, and the wound closed with sterilized catgut.

The operation was repeated on the other side, after which the scrotum was washed with sublimate solution, the released leg again secured to the table and the patient allowed to recover from the anæsthetic, when he was returned to the general ward, where he was fed light for the first few days. Any deviation

from this plan will be mentioned under the report of such cases.

Report of Animals Operated Upon.—No. I (546) was a black stallion, thirteen years old, weight about 1200 pounds, in good condition. Sept. 26, 1897, admitted to general ward and prepared for operation; Sept. 27th, 2 P. M., patient placed upon operating table and operated upon under strict aseptic precautions; closed wound with interrupted sutures; dressed with iodoform. Sept. 28th, 8 A. M., temp. 100.2; 4 P. M., temp. 100.1; very slight amount of serum exuding from wound. Sept. 29th, temp. 2 P. M., 100.2; 4 P. M., 100.2. There were a few drops of serum exuding from the wound. Sept. 30th, 9 A. M., temp. 100; 4 P. M., temp. 100.4; no discharge of serum from wound. Oct. 1, 9 A. M., temp. 100.2; no discharge from wound. While animal was under observation, the scrotum was washed once daily, with sublimate solution, 1–1000. The owner removed animal Oct. 1st and reported later that the wounds healed without any suppuration.

No. II. (516) was a bay stallion, three years old; weight about 1000 pounds, in medium condition. Sept. 30, 1897, admitted to ward and prepared for operation. Oct. 1, 2 P. M., placed animal upon operating table and operated under strict aseptic precautions, closed wound with interrupted sutures; dressed with iodoform. Oct. 2d, 9 A. M., temp. 101.2; pulse 36, resp. 12; 2 P. M., temp. 101.2; pulse 36, resp. 12; animal eating half ration; very slight exudation of serum from wound. Oct. 3d, 9 A. M., temp. 101.1, pulse 38, resp. 12; 6. P. M., temp. 101.; pulse 36, resp. 12; animal eating well; looking well; no exudation of serum from scrotum. Oct. 4th, 9 A. M., temp. 101, pulse 37, resp. 12; animal looks well; scrotum still somewhat enlarged. While under observation the scrotum was washed once daily with sublimate solution, 1–1000.

The owner removed animal Oct. 4th, and reported later that the wound healed without any suppuration.

No. III. (738) was a large well developed Berkshire boar, five years old, in good condition, weight about five hundred

pounds. Feb. 2, 1898, admitted to ward 2 P. M., was thrown and confined with ropes; the scrotum, scrubbed with soap and water, then rinsed off with sublimate solution, 1–1000, and this washed off with boiled water, then proceeded with the operation. The testicles were removed through small incisions in the lower portion of the scrotum; the cord was ligated and severed below ligature with the emasculator. The wound was closed with a continuous suture of silk and the scrotum wet with sublimate solution. Feb. 3d, the animal, stiff from struggling when tied, but bright, eating half ration. Scrotum about as large as before operating; no discharge of serum. Feb. 4th, scrotum about the same; no serum from wounds; appetite better. Feb. 5th, scrotum slightly decreased in size; no discharge of serum from wounds. Feb. 6th, animal very lively; scrotum slightly smaller. Feb. 7th, animal eats all he can get; scrotum about two-thirds as large as before operating. Feb. 8th, scrotum about one-half size as it was before operating, and the epithelium appears to have joined over the wounds. Feb. 9th, scrotum about one-third original size, and as wound seemed to be entirely covered with epithelium, the patient was discharged.

The owner reported later that the animal recovered without incident.

No. IV. (855) was a dark bay stallion, five years old, weight about 1050 pounds, in medium condition; Mar. 24, 1898, admitted to ward and prepared for operation. Mar. 25, 11 A. M., placed animal upon operating table and operated under strict aseptic precautions, closed wounds in scrotum with continuous suture of catgut. There was some subcutaneous hæmorrhage, which produced a hematom on the right side. This was about the size of the testicle. 4 P. M., temp. 100; pulse 40; resp. 13. Mar. 26th, 8 A. M., temp. 101.1; pulse 43; resp. 12. 8 P. M., temp. 101.1; pulse 38; resp. 14; animal bright; scrotum about the same size; nothing exuding from the wound. Mar. 27th, 9 A. M. temp. 100.8; pulse 36; resp. 12; no exudation from wounds. Mar. 28th, 9 A. M., temp. 101.6; pulse 36;

resp. 12; 3 P. M., temp. 101.9; pulse 36; resp. 12; scrotum about the same. Mar. 29th, 8 A. M., temp. 100.6; pulse 40; resp. 12; 3 P. M., temp. 102.1; pulse 38; resp. 12; the scrotum has decreased in size somewhat, but the sheath has become œdematous. Mar. 30th, 8 A. M., temp. 100.2; pulse 36; resp. 12; animal is in good spirits, but during the night broke the sutures on the right side (this being the side that the hematom was on); the wound was now opened, the clot removed, and the parts irrigated with sublimate solution, 1–1000. A portion of the clot was taken and agar and bouillon tubes inoculated with it. 3 P. M., temp. 100.2; pulse 36; resp. 12. Mar. 31st, 8 A. M., temp. 103; pulse 46; resp. 15; 3 P. M., temp. 101.8; pulse 38; resp. 12; scrotum about the same size; no pus on the right side. Apr. 1st, 8 A. M., temp., 101.8; pulse 40; resp. 12; 3 P. M., temp. 103; pulse 50; resp. 14; opened and washed out left side, but there was no infection seemingly. The swelling has gone down greatly. Apr. 2d, 8 A. M., temp. 105; pulse, 48; resp. 14. Animal dull, did not eat entire breakfast. 3 P. M., temp. 106; pulse 68; resp. 16; washed out both wounds in scrotum, with sublimate solution, also gave ball composed of Barbadoes aloes, drachms vi; sulph. quinine, ounce 1. Apr. 3d, 8 A. M., temp. 103.8; pulse 64; resp. 14. 3 P. M., temp. 104.2; pulse 55; resp. 14; animal eating well; no pus from wound. Apr. 4th, 8 A. M., temp. 104.5; pulse 42; resp. 14; very slight swelling of scrotum; no pus. Apr. 5th, 8 A. M., temp. 101; pulse 46; resp. 12; 3 P. M., temp. 102; pulse 42; resp. 12; no pus. Apr. 6th, 8. A. M., temp. 102.4; pulse 42; resp. 12; 3. P. M., temp. 102.6; pulse 42; resp. 12. Apr. 7th, 8 A. M., temp. 100.4; resp. 12; pulse 38; 3 P. M., temp. 100.2; pulse 36; resp. 12; the scrotum normal in size; the left wound has closed entirely, the right nearly closed. Apr. 8th, 8 A. M., temp. 99.8; pulse 36; resp. 12; 2 P. M., temp. 100; pulse 36; resp. 12; no discharge from wound. The owner took animal home and reported ten days later that the wound healed without any perceptible pus formation. The cultures that were made from the hematom on Mar. 30th, developed a pure culture of the

staphylococcus pyogenes aureus. Each day the animal was under observation, the scrotum was washed twice daily with sublimate solution 1–1000.

No. V. (879) was a dark bay stallion, six years old, weight about 1000 pounds, in good condition. Apr. 1, 1898, admitted to ward and prepared for operation. Apr. 2d, 9 A. M., animal placed upon table and operated upon under strict antiseptic precaution; closed wounds with interrupted sutures. Apr. 3d, 9 A. M., temp. 101; resp. 14; pulse 38; 5 P. M., temp. 101.2; resp. 14; pulse 40; animal bright, eating well; scrotum about size as before operating. Apr. 4th, 8. A. M., temp. 101.2; pulse 40; resp. 14; 3 P. M., temp. 101.3; pulse 40; resp. 14; scrotum same; no exudation of serum. Apr. 5th, 8 A. M., temp. 100.4; pulse 36; resp. 12; 3 P. M., temp. 101; pulse 38; resp. 12. Apr. 6th, 8 A. M., temp. 101; pulse 44; resp. 14; 3 P. M., temp. 101.2; pulse 42; resp. 12; scrotum about the same; no exudation of serum. Apr. 7th, 8 A. M., temp. 101; pulse 40; resp. 12; 3 P. M., temp. 100.8; pulse 37; resp. 12. Apr. 8th, 8 A. M. temp. 100.6; pulse 38; resp. 12; 3 P. M., temp. 101; pulse 38; resp. 12; scrotum considerably smaller; no exudation from wound. Apr. 9th, 8 A. M., temp. 100; pulse 36; resp. 12; 3 P. M., temp. 100.8; pulse 38; resp. 12; scrotum about one-half original size. The epithelium has united over the wounds, so that the patient was discharged at this time.

No. VI. (1027) was a bay yearling colt of medium size, in fair condition. May 3, 1898, admitted to ward and prepared for operation. May 4th, 11 A. M., placed animal upon operating table and operated under usual precautions. The cord was ligated with sterile silk and the scrotal wounds closed with interrupted sutures of sterile silk, and over this wound gelatin applied (8). May 5th, 9 A. M., temp. 101.6; 3 P. M., temp. 101.5; very slight swelling of scrotum. May 6th, 3 P. M., temp. 101.3. May 7th, 3 P. M., temp. 102.2. May 8th, 9 A. M., temp. 101.6. May 9th, 9 A. M., temp. 102.7. May 10th, 3 P. M., temp. 101. May 11th, animal discharged. During time since operation, the animal was bright and ate well. To-day the wounds appear

to be covered with epithelium. There was no exudation of serum at any time.

No. VII. (1029) was a yearling colt of medium size in fair condition. May 4, 1898, admitted to ward and prepared. May 5th, placed animal upon operating table and operated under aseptic precautions; the cord was ligated with silk, and the scrotal wounds were closed with a continuous suture of sterile silk, over which was applied wound gelatin. May 6th, temp. 100.6; scrotum was not swollen at all; the patient was feeling well. May 7th, 8 A. M., temp. 101.8; 3 P. M., temp. 102; very slight swelling of scrotum. May 8, 8 A. M., temp. 102; 3 P. M. 101. May 9th, 8 A. M., temp. 101.6; 3 P. M., 101.8. May 10th, 8 A. M., temp. 101.5; 3 P. M., temp. 100. May 11th, temperature was not taken. May 12th, 2 P. M., temp. 101.2; animal discharged. During the time since operating the patient had been in good spirits and eating well, and there had been no discharge of serum from wounds. When discharged the epithelium was united over the wounds.

No. VIII. (1025) was a brown four-year-old colt, in medium condition; weight about 950 lbs. May 2, 1898, admitted to ward and prepared for operation. May 3d taken to operating room and operated upon under septic precautions. The covered operation was performed and was ligated with silk; scrotal wounds closed with continuous suture of silk. May 4th, 4 P. M., temp. 101; scrotum swollen somewhat. May 5th, 9 A. M., temp. 101.7; 3 P. M., 102.2. May 6th, 9 A. M., temp. 100.7; 3 P. M., temp. 101.7; swelling of scrotum much increased. May 7th, 9 A. M., temp. 101; 3 P. M., temp. 101.9; scrotum about the same. May 8th, temperature not taken. May 9th, 9 A. M., temp. 105.5; 3 P. M., 102.8; scrotum very badly swollen and suppurating somewhat. Opened up wounds and found a large hematom on each side, which was doubtless due to the spermatic artery slipping upward out of the ligature and bleeding quite extensively. Removed hematom and washed out scrotal cavities with sublimate solution. May 10th, 9 A. M., temp. 101.6; 3 P. M., temp. 103.4; swelling markedly decreased; slight discharge. May 11th, 3 P.

M., temp. 103; swelling still decreasing. May 12th, 9 A. M., temp. 101.3; 3 P. M., temp. 101. May 13th, 9 A. M., temp. 100.6; 3 P. M., temp. 102.4; swelling about disappeared; no discharge. Each day, since opening wounds in scrotum, it was washed out with sublimate solution; discharged.

No. IX. (1055) was a black four-year-old colt, weight about 1000 lbs., in good condition. May 9, 1898, admitted to ward and prepared for operation. May 10th, placed upon operating table and operated upon under aseptic precautions; ligated the cords with silk; closed wound with continuous sutures of silk, over which was placed wound gelatin; at 4 P. M., temp. 101. May 11th, 3 P. M., temp. 100.6; scrotum swollen very little. May 12th, 9 A. M., temp. 100.7; 3 P.M., temp. 101; no change in scrotum. May 13th, 9 A. M., temp. 99.8; 3 P. M., temp. 100.8. May 14th, 3 P. M., temp. 100.8; slight decrease in swelling of sheath. May 15th, 9 A. M., temp. 99.4. May 16th, 9 A. M., temp. 100.5; 3 P. M., temp. 100.5; there is no appreciable swelling in sheath or scrotum. May 17th, 9 A. M., temp. 100. The epithelium is apparently closed over the wounds; patient was discharged.

No. X. (1062) was a bay colt, one year old, of medium size and in moderate condition. May 10, 1898, admitted to general ward and prepared for operation. May 11th, the animal was placed on operating table and operated upon under aseptic precautions, ligated the cord with silk, closed scrotal wounds with silk, and applied wound gelatin. Temperature before operating, 101.2. May 12th, 9 A. M., temp. 101.2; 3 P. M., temp. 101.8; no swelling of scrotum. May 13th, 9 A. M., temp. 101.2; 3 P. M., temp. 102.2. There is a very slight swelling of the scrotum. May 14th, 3 P. M., temp. 102.2; swelling about the same. May 15th, temperature not taken. May 16th, 3 P. M., temp. 101. May 17, colt out in paddock, did not take temperature. May 18th, discharged; the scrotum not swollen, and the wound apparently closed over with epithelium.

No. XI. (1063) was a bay stallion, seven years old; weight about eleven hundred pounds, in medium condition. May 11,

1898, animal admitted to general ward and prepared for operation. May 12th, 11 A. M., placed upon operating table and operated upon under aseptic precautions, ligated the spermatic artery with silk, closed scrotal wounds with silk, and applied wound gelatin; 11.40 A. M., temp. 100.6, animal recovering from anæsthetic; 2 P. M., temp. 99.4. May 13th, 9 A. M., temp. 101; 2 P. M., temp. 100.8; very slight swelling of scrotum. May 14th, 9 A. M., temp. 101.2; 2 P. M., temp. 101.2; scrotum about same. May 15th, 9 A. M., temp. 102.6; 6 P. M., temp. 101.7; animal quite constipated, for which gave laxative. May 16th, 9 A. M., temp. 100.5; 3 P. M., temp. 101.6. May 17th, 9 A. M., temp. 101.9; 2 P. M., temp. 101.6; scrotum not swollen at all. May 18th, temp. 102; 2 P. M., temp. 101.8. May 19th, 3 P. M., temp. 100.8. The wounds are apparently covered with epithelium; discharged. During the last five days animal was badly constipated, but fully recovered before discharged.

No. XII. (1056) was a black colt, three years old, weight about 900 lbs., in good condition. May 9, 1898, admitted to general ward and prepared for operation. May 10th, placed on table and operated under aseptic precautions; ligated the spermatic artery with silk and closed scrotal wounds with a continuous suture of silk. The animal was removed from table before he was able to stand and causing him to fall, soiling the scrotum and rubbing off the wound gelatin which had been applied. When he had recovered sufficiently to stand, the scrotum was washed with sublimate solution, and the patient returned to the general ward. May 11th, 9 A. M., temp. 101.2; pulse 39; resp. 14; 3 P. M., temp. 101.2; pulse 39; resp. 14; scrotum about two-thirds original size. May 12th, 9 A. M. temp. 100.6; pulse 36; resp. 12; 3 P. M., temp. 101; pulse 36; resp. 12. May 13th, 9 A. M., temp. 100.6; pulse 36; resp. 12; 3 P. M., temp. 101; pulse 44; resp. 14; scrotum swollen moderately; the sheath swollen somewhat more. May 14th, 9 A. M., temp. 103; resp. 12; pulse 44; 3 P. M., temp. 102.4; resp. 12; pulse 46. May 15th, 9 A. M., temp. 101.4; pulse 39; resp. 12. May 16th, 9 A. M., temp. 101; pulse 37; resp. 12; 3

P. M., temp. 102 ; pulse 36. A suture was broken on the right side, and there was a small amount of serum exuding. May 17th, 9 A. M., temp. 101.6 ; pulse 38 ; resp. 12 ; 3 P. M., temp. 102.2 ; pulse 38 ; resp. 12 ; the serum still continues to exude from right side ; the left side is doing finely ; swelling of scrotum much decreased. May 18th, 9 A. M., temp. 101.1 ; pulse 36 ; resp. 12 ; 3 P. M., temp. 101 ; pulse 38 ; resp. 12 ; slight discharge of serum from right side. May 19th, 9 A. M., temp. 101 ; pulse 36 ; resp. 12 ; 3 P. M., temp. 101 ; pulse 36 ; resp. 12. May 20th, 9 A. M., temp. 100.4 ; pulse 36 ; resp. 12 ; 3 P. M., temp. 100.4 ; pulse 36 ; resp. 12 ; the sheath and scrotum is still slightly swollen ; the left wound has healed by primary adhesion ; and the right is healing by secondary intention, without perceptible pus formation.

No. XIII. (1069) was a brown colt, two years old ; weight about 800 lbs., in poor condition. May 12th, admitted to ward and prepared for operation. May 13th, placed upon table and operated upon, under aseptic precautions ; ligated spermatic artery with silk, closed scrotal wounds with a continuous suture of silk. May 14th, 9 A. M., temp. 101.3 ; 3 P. M., 102 ; very slight swelling of scrotum. May 15th, 9 A. M., temp. 101.8 ; 3 P. M., temp. 102. May 16th, 9 A. M., temp. 101.1 ; 3 P. M., temp. 100.8 ; swelling of scrotum gone down. May 17th, 9 A. M., temp. 101.4 ; 3 P. M., temp. 100.8. May 18th, 9 A. M., temp. 100.1. May 19th, 3 P. M., temp. 100. May 20th, 3 P. M., temp. 100 ; wounds healed over ; patient discharged.

SUMMARY.

The only literature available upon this subject is an article by Frick (6), in which he speaks of Bayer operating upon fifteen cases under aseptic precautions, where he had healing by primary adhesion in four cases on both sides, and in two cases on one side, so that out of thirty operation wounds, ten healed by primary adhesion or thirty-three and one-third per cent. The other wounds healed according to Bayer's opinion better than where operated upon with clamps. Frick, in speaking of Bayer's op-

eration, says he does not think it is practical in private practice, as Bayer only ligated the spermatic artery, and when the animal got up there would be bleeding from the veins.

TEMPERATURE CHART.

No. of Case.	Temp. day of Operation.	Temperature after operation.									
		1st day	2d day.	3d day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	10th day.
I.—9 A. M.	Not	100.2	100.2	101.	100.4						
3 P. M.	taken.	100.1	100.2	100.4							
II.—9 A.M.	Not	101.2	101.1	101.							
3 P. M.	taken.	101.2	101.1	.....							
III.—9 A.M.	Tem	peratu	re not	taken.							
3 P. M.											
IV.—9 A.M.	.....	101.1	100.8	100.6	100.2	103.	101.8	105.	103.8	104.5	101.
3 P. M.	100.	101.1	101.9	102.1	100.2	101.	103.	106.	104.2	103.5	102.
V.—9 A.M.	.....	101.	101.2	100.4	101.	101.	100.6	100.			
3 P. M.	100.	101.2	101.3	101.	101.2	100.8	101.	100.8			
VI.—9 A.M.	Not	101.6	.....	.....	101.6	102.7					
3 P. M.	taken.	101.5	101.8	102.2	.....	.....	101.				
VII.—9 A.M.	Not	100.6	101.8	102.	101.6	101.5	Not				
3 P. M.	taken.	.....	102.	101.	101.8	100.	taken.	101.2			
VIII.—9 A.M.	Not	....	100.7	100.7	101.	Not	105.8	101.6		101.3	100.6
3 P. M.	taken.	101.	102.2	101.7	101.9	taken.	102.8	103.4	103.	101.	102.4
IX.—9 A.M.		.....	100.7	99.8	.....	9 .4	100.5	100.			
3 P. M.	101.	100.6	101.	100.8	100.8	.....	100.5				
X.—9 A.M.		101.2	101.2	.....	Not	.....					
3 P. M.	101.2	101.8	102.2	102.2	taken.	101.					
XI.—9 A.M.		101.	101.1	102.6	100 5	101.9	102.				
3 P. M.	99.4	100.8	101.2	101.7	101.6	101.6	101.8	100.8			
XII.—9 A.M.	Not	101.2	100.6	100.6	103.	101.4	101.	101.6	101.1	101.	100.4
3 A.M.	taken.	101.2	101.	101.0	102.4	.....	102.	102.	101.	101.	100.4
XIII.—9 A.M.	Not	101.3	101.8	101.1	101.4	100.1					
3 P. M.	taken.	102.	102.	100.8	100.8	.....	100.2	100.1			

Frick operated upon some animals under aseptic precautions by what he considered a more practical method. His method was, one-half hour before operating, the animal was given .5 grammes hydrochlorate of morphine. The animal was placed upon his back, and the scrotum, sheath, inner thighs and neighboring parts washed with soap and water. This was rinsed off with sublimate solution, 1-1000, then an incision was made in the scrotum, barely large enough to allow the testicle to be pressed out; when the testicle was exposed, an assistant poured sublimate solution over it. The testicular cord was perforated just anterior to the vas deferens, making two portions, and ligated each portion firmly with sublimated silk. To prevent the

No. of Case.	Initial of Operator.	Previous experience in Castration.	Previous experience with the Aseptic Operation.	Mode of Operation.	Mode of Healing.	Complications.
I.	H. W. D.	None.	None.	Ligated spermatic cord. Closed scrotal wounds with interrupted sutures (catgut).....	Primary adhesion.	None.
II.	A. B. K.	2 cases.	do	do	do	do
III.	R. J. S.	15 cases.	do	Ligated cord, closed scrotal wounds with continuous sutures silk).....	do	do
IV.	R. J. S.	do	Case III.	do (catgut)	Secondary intention without suppuration.	Hæmatoma and infection.
V.	R. J. S.	do	Case III and IV.	Interrupted sutures (catgut) do.....	Primary adhesion.	None.
VI.	H. J. L.	None.	None.	Continuous sutures (silk) do.....	do	do
VII.	C. R. P.	do	do	do (used wound gelatin).....	do	do
VIII.	W. L. W.	400 cases.	*	Covered operation, silk ligatures, wound gelatin...	Secondary intention.	Hæmatoma and infection.
IX.	C. W. G.	None.	None.	Ligated cord, silk sutures. wound gelatin.....	Primary adhesion.	None.
X.	W. J. M.	do	do	Ligated cord, continuous sutures (silk), wound gelatin.....	do	do
XI.	A. B. K.	2 cases.	Case II.	Ligated spermatic artery; closed scrotal wounds with continuous sutures (silk gelatin).....	do	do
XII.	R. J. S.	15 cases.	Case III, IV and IV	Ligated spermatic artery. Closed scrotal wounds with continuous sutures (silk) (gelatin).....	Primary adhesion (one side).	do
					Secondary intention (one side).	do
XIII.	C. B. P.	None.	None.	do.....	Primary adhesion.	do

* Had attempted aseptic operation on six horses without chloroform; four by covered operation and two by baring testicles, washing the wounds with sublimate solution, 1-1000, and closing with sutures, none of which were successful.

ligature slipping off, a part of the epididymis was allowed to remain on the cord, when the testicle was excised. This, he says, is aseptic and is resorbed. The scrotal sac was washed out with sublimate solution and the wound closed with sutures. The operation was repeated upon the opposite side, and the animal allowed to rise, when the scrotum was again washed with sublimate solution. The instruments used and the operator's hands were disinfected with sublimate solution, 1-1000. There occurred in most of his cases, on the second or third day after operating, a fever, which, he says, may attain 103.6° F., but which was due to aseptic resorption fever and can be differentiated from septic fever, as the animal is bright and eats well in the former, while in the latter there is dullness and no appetite. But in comparison with the results obtained here, it would appear that, where the temperature ran up as high as 103.6° F., there was infection, as is illustrated by case No. IV. Here the animal was bright; but from the clot there was obtained a pure culture of *staphylococcus pyogenes aureus*. The only complication which followed his operation was bleeding, which sometimes appeared after the horse had risen. Frick thinks this is subcutaneous, and says that it does not interfere with healing unless it is abundant so as to press the edges of the wound apart and that hematomata the size of a child's head are readily absorbed.

If larger hematomata appear, the sutures should be taken out on the fourth or fifth day, the clot removed, and the wound rinsed out once daily with sublimate solution, until healing occurs. It is noteworthy in these cases that we have healing by secondary intention, without suppuration. He castrated twelve horses, which varied in size from a pony to a very heavy draft animal, and in seven cases there was healing by primary adhesion on both sides; in two cases on one side. The remaining wounds healed by secondary intention, so in twenty-four wounds, sixteen healed by primary adhesion, or sixty-six two-thirds per cent; but from the results obtained in our operations it seems that it would decrease the danger to use boiled or distilled water

to wash the scrotum before making the incisions, and also to wash away any blood after the testicle is exposed, and thus not allow any of the sublimate solution to enter the peritoneal sac of the scrotum, which would increase the danger of infection with the pus producing organisms (7), as the sublimate would act as a chemical irritant and produce the death of the adjacent cells, which would be a medium for bacteria to live upon until they gained a foot-hold and as the sublimate would combine with the albumen of the tissues and form an albuminate, it would not have any inhibitory action upon their growth ; while if such a few obtained entrance without the sublimate solution, the living cells would be able to overcome them and we would have practical sepsis.

Of the thirteen cases operated upon here, ten healed by primary adhesion on both sides and one on one side. The remaining wounds healed by secondary intention, which was much more rapid than it is by the usual methods of leaving the wound open, and in two of these wounds that healed by secondary intention, there was no perceptible pus formation. In all, there were twenty-six wounds, of which twenty-one healed by primary adhesion or eighty per cent. The only complications occurring being hematoma in cases IV and VIII. In case IV the cord was ligated with catgut, which had been preserved in alcohol and which after being applied gradually became softened by the lymph in the tissues and relaxing allowed the spermatic artery to bleed. In case VIII, the covered operation was performed and the ligature was passed around the envelopes and the cord, but was not drawn sufficiently tight to thoroughly compress and retain the spermatic artery. The ligation over the inner envelopes in the covered operation would be practical in yearling colts and those under that age, but would not be practical, as a rule, in those older than one year.

The temperature of those animals which healed by primary adhesion did not exceed 102.4° F., as reference to the chart on pages 18 and 19 will show, and only in those cases where there was infection was there a high temperature. This would make

it appear that the high temperatures reported by Frick were due either to slight infection, or to the introduction of an irritant into the scrotum in the form of the sublimate solution, and that it was not due to the resorption of the ligated end of the cord; but the time at which his high temperatures occurred corresponds to the date at which infection fever usually takes place.

In carrying on these operations, it was found best to make some changes, which appeared to be and proved more practical. The first was the use of sterile silk instead of catgut to ligate the spermatic cord.

The use of silk to close the scrotal wounds was also found best. This was used both as interrupted and continuous sutures. The interrupted suture was found to give the best results, as it was only with the continuous suture that there was any infection, though there were a number which healed by primary adhesion, where the continuous suture was used.

The use of some agent, such as wound gelatin, to apply to the wounds after operation was performed was found to be much more convenient, as it does away with the necessity of applying antiseptics to the scrotum daily until healing occurs. There may be other agents, which would answer the same purpose. The requirements are:

A substance which can be applied to a moist surface and will stick, and when dry it must be flexible and not crack when bent. The agent in itself must be sterile and capable of remaining so. The method of ligation of the spermatic artery which was performed in the last three cases deserves still further trial, as in two cases there was very little swelling, practically none. In case XII there was considerable swelling, but this can be accounted for by the accident caused by removing the animal from the table before it was able to stand. The principal reason to recommend this method is that we introduce a smaller ligature and cause the death of a less amount of tissue, which must be resorbed.

The objection raised to the performance of the aseptic opera-

tion in private practice is that it is not practical and that it requires a skilled operator and great care in reference to technique. The objections can be refuted by reference to the condensed table on pages 18 and 19. This gives the previous experience of the operator in castration, the previous experience with the aseptic operation, the mode of operating and the results obtained. By reference to this, it will be seen that nine different men operated during this series of observations, six of whom had not castrated an animal before, and yet every one of these obtained healing by primary adhesion.

It would appear that if the operation could be carried out successfully by an inexperienced student, that it would be practical in private practice, especially with a surgeon, who has become skillful in the manipulation of the testicle, and who has a thorough knowledge of aseptic surgery. The operating table was used as the method of restraint in connection with the use of a general anæsthetic in these cases, though it would appear that casting an animal upon clean, green turf would be as successful, but the general anæsthetic is almost a necessity to obtain practical antisepsis.

With the present methods of operating, and after treatment of the wounds, the veterinarian cannot expect to obtain any better results than the empiric, who uses the same methods and can do the operation for a much smaller fee than the veterinarian.

It is only under such conditions as will lessen the dangers of it that the veterinarian can expect to command this important operation with proper compensation.

I think that the conclusions that can be drawn from the results of this series of operations are :

First.—The aseptic operation is a practical success in the clinic.

Second.—It would be a practical success in private practice.

Third.—By aseptic methods, we lessen the dangers of castration, and should therefore be able to command these operations.

Fourth.—With our present knowledge of bacteriology, we owe it to the veterinary profession and to our clients, that we should perform all operations by antiseptic methods.

In closing this paper, I would like to acknowledge the assistance received from Profs. W. L. Williams, James Law, V. A. Moore and Mr. R. C. Reed.

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"There is hereby established a State Veterinary College at Cornell University." Laws of New York, 1894, p. 307.

ANNOUNCEMENT

OF THE

NEW YORK STATE

VETERINARY COLLEGE

AT

CORNELL UNIVERSITY

1898-99

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TABLE OF CONTENTS

PAGE

Calendar ..... Second page of cover
Table of Contents 2
Officers of Administration 3
Faculty 3–4
Veterinary College Directory 4
Foundation and Objects of the College 5–6
Buildings and Location 7
Admission on Certificate 8–9
Admission on Examination 9–19
Admission to Advanced Standing 19
Time of Examinations ..... Second page of cover
Admission to Graduate Work 20
Residence and Registration 20
Requirements for Graduation 20, 22
Schedule of the Courses of Instruction 20–21
Departments, Methods and Facilities 22–37
- Chemistry 22
- Anatomy 23
- Comparative Physiology 25
- Microscopy, Histology and Embryology 26
- College of Agriculture, Breeds and Breeding 28
- Pharmacology and Therapeutics 29
- Medicine, Sanitary Science and Parasitism 30
- Surgery, Zoötechny, Obstetrics and Jurisprudence 31
- Pathology, Bacteriology and Meat Inspection 35

Graduate and Research Work 37
Library Facilities 37
The Roswell P. Flower Veterinary Library 37
Veterinary College Seminary 38
Society of Comparative Medicine 38
Tuition and Laboratory Fees; other Expenses 38–39
Horace K. White Prizes 39
Position as Demonstrator 39
Appendix A. Openings for Veterinarians in America 40
Appendix B. Legal requirements of preparatory and professional study for graduation in Veterinary Medicine in the State of New York. Requirements for License to practice Veterinary Medicine in the State of New York 8, 41
Catalog of Veterinary College Students for the year 1897–1898 43

OFFICERS OF ADMINISTRATION

OF THE

NEW YORK STATE VETERINARY COLLEGE

The Board of Trustees of Cornell University, in which are included the following State Officers: His Excellency the Governor, His Honor, the Lieutenant-Governor, the Speaker of the Assembly, the Superintendent of Public Instruction; also the President of the State Agricultural Society, and the Commissioner of Agriculture.

Veterinary College Council.

The President of Cornell University, JACOB G. SCHURMAN.
The Director of the Veterinary College, *Professor* JAMES LAW.
The Treasurer of Cornell University, EMMONS L. WILLIAMS.
Professor WALTER L. WILLIAMS.
Professor SIMON H. GAGE.
CHARLES EZRA CORNELL, *Secretary of the Council.*

FACULTY OF THE NEW YORK STATE VETERINARY COLLEGE.

JACOB GOULD SCHURMAN, A.M., D.Sc., LL.D., *President.*

JAMES LAW, F.R.C.V.S., *Professor of Principles and Practice of Veterinary Medicine, Veterinary Sanitary Science, and Parasitism.*

WALTER L. WILLIAMS, D.V.S., *Professor of Principles and Practice of Veterinary Surgery, Obstetrics, Zoötechny, and Jurisprudence.*

PIERRE AUGUSTINE FISH, D.Sc., D.V.S., *Assistant Professor of Comparative Physiology, Pharmacology and Therapeutics.*

VERANUS ALVA MOORE, B.S., M.D., *Professor of Comparative Pathology and Bacteriology, and of Meat Inspection.*

SIMON HENRY GAGE, B.S., *Professor of Microscopy, Histology and Embryology.*

GRANT SHERMAN HOPKINS, D.Sc., *Assistant Professor of Veterinary Anatomy and Anatomical Methods.*

BENJAMIN FREEMAN KINGSBURY, A.B., Ph.D., *Instructor in Microscopy, Histology and Embryology.*

RAYMOND CLINTON REED, Ph.B., *Instructor in Comparative Pathology and Bacteriology.*

——— ———, *Demonstrator of Anatomy.*

PROFESSORS AND TEACHERS IN CORNELL UNIVERSITY WHO FURNISH INSTRUCTION TO VETERINARY STUDENTS.

GEORGE CHAPMAN CALDWELL, B.S., PH.D., *Professor of Agricultural and Analytical Chemistry.*

ISAAC PHILLIPS ROBERTS, M.AGR., *Professor of Agriculture.*

WILLIAM RIDGELY ORNDORFF, A.B., PH.D., *Assistant Professor of Organic and Physiological Chemistry.*

HENRY HIRAM WING, M.S., *Assistant Professor of Animal Industry and Dairy Husbandry.*

FREDERICK LAWRENCE KORTRIGHT, D.Sc., *Instructor in Chemistry.*

VETERINARY COLLEGE DIRECTORY.

The President of the University, JACOB G. SCHURMAN, 2 Morrill Hall.

The Dean of the Veterinary College, Professor JAMES LAW, Room 2, s. e. corner, 1st floor of the Veterinary College.

Professor WALTER L. WILLIAMS, Room 3, n. w. corner, 1st floor.

Professor PIERRE A. FISH, Room 11, n. w. corner, 2d floor.

Professor GRANT S. HOPKINS, Room 12, n. e. corner, 2d floor.

Professor VERANUS A. MOORE, Room 13, s. w. corner, 3d floor.

Professor SIMON H. GAGE, Room 14, s. e. corner, 3d floor.

Instructor B. F. KINGSBURY, Room 18, n. e. corner, 3d floor.

Instructor RAYMOND C. REED, Room 17, n. w. corner, 3d floor.

Veterinary College Clerk, CHARLES EZRA CORNELL, Room 1, s. w. corner, 1st floor.

The Stud Groom, GEORGE I. BOVIER, Cottage east of Main Building (see plan, p. 7).

FOUNDATION.

The New York State Veterinary College was established by act of the State Legislature in 1894. "There is hereby established a State Veterinary College at Cornell University," Laws of New York 1894, p. 307. By action of the Board of Trustees of Cornell University, June 10, 1894, the location of the College upon the University Campus was authorized. It was further enacted that while the University does not undertake any financial responsibility for the buildings, equipment or maintenance of the College, it does consent to furnish instruction upon such subjects as are or shall be in its curriculum upon such terms as may be deemed equitable.

By further acts of the Legislature provision for the buildings, equipment and maintenance of the College were made and finally in 1897, by "An act to provide for the administration of the State Veterinary College, established by chapter 153 of the laws of 1894," it was enacted that the Trustees of Cornell University should be entrusted with the administration. (For officers of administration, see p. 3).

OBJECTS OF THE INSTITUTION.

As stated in the act to provide for the administration of the State Veterinary College: "*The State Veterinary College, established by chapter 153 of the laws of 1894, shall be known as the New York State Veterinary College. The object of said veterinary college shall be: to conduct investigations as to the nature, prevention and cure of all diseases of animals, including such as are communicable to man and such as cause epizootics among live stock; to investigate the economical questions which will contribute to the more profitable breeding, rearing and utilization of animals; to produce reliable standard preparations of toxins, antitoxins and other products to be used in the diagnosis, prevention and cure of diseases and in the conducting of sanitary work by approved modern methods; and to give instruction in the normal structure and function of the animal body, in the pathology, prevention and treatment of animal diseases, and in all matters pertaining to sanitary science as applied to live stock and correlatively to the human family.*"

The New York State Veterinary College was therefore founded to raise the standard of veterinary instruction and investigation to the level

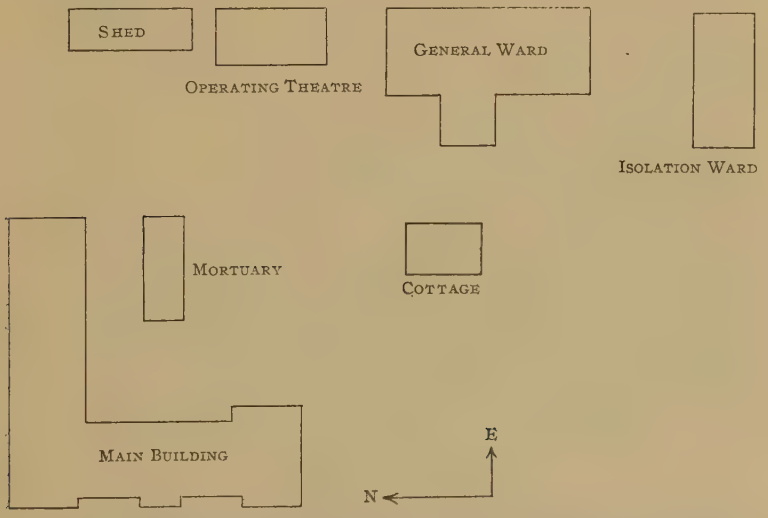
of the most recent advances in biology and medicine. The number of farm animals in this State (9,450,000), and their value ($131,200,000), with a yearly product, in milk alone, of over 5,000,000,000 gallons, give some idea of the great interest at stake in the matter of live stock. For the United States a value in live stock of, approximately, $2,000,000,000, and a yearly sale, in Chicago alone, of $250,000,000 worth, bespeak the need of all that learning and skill can do for the fostering of this great industry. Another consideration is that the normal permanent fertilization of the soil is dependent on the live stock kept, and that where there is a deficiency of animals, the productiveness of the land is steadily exhausted; so that the health and improvement of animals and the fostering of animal industry, lie at the very foundation of our national wealth. Another, and no less potent argument, for the highest standard of veterinary education, is its influence on the health of the human race. With a long list of communicable diseases, which are common to man and beast, and with the most fatal of all human maladies—tuberculosis—also the most prevalent affection in our farm herds in many districts, it is to the last degree important that measures for the extinction of such contagion in our live stock should receive the best attention of the most highly trained experts.

To justify the liberality of the State in creating this seat of learning, it will be the aim of the College to thoroughly train a class of veterinarians for dealing with all disease and defects that depreciate the value of our live stock, and with the causes which give rise to them; to recognize and suppress animal plagues, which rob the stock owner of his profits, and cause widespread ruin; to protect our flocks and herds against pestilences of foreign origin, and to protect human health and life against diseases of animal origin. It will further aim, so far as it has the means and opportunity, at establishing a center of investigation, looking towards such improvements in the breeding, care and management of animals as may enhance their market value and make returns more speedy and profitable; towards discoveries in therapeutics, and the immunization of animals and men from contagion; and towards the production of organic compounds to be employed in diagnosis, treatment and immunizing. So much has been recently discovered in these directions, and present knowledge points so unmistakably to coming discovery, that to neglect this field at the present time would be decidedly reprehensible. Apart from discovery, the mere production of reliable articles of these organic products which are coming into increasing demand by the State and private practitioner, for prevention, diagnosis and treatment, is an object not to be lightly set aside. The combination in one institution of educational facilities with scientific investigation, and the production of the organic extracts to be employed in modern medical methods, is a feature calculated to insure the best work in all departments, and the most exceptional advantages for the diligent student.

LOCATION AND BUILDINGS.

The New York State Veterinary College is located at Ithaca, on the campus of Cornell University, fronting on East Avenue, and facing the University buildings. Electric cars on East Avenue convey students and visitors to any part of the city. Ithaca, with its population of 12,000, is situated at the head of Cayuga Cake, 262 miles distant from New York City, and on the lines of the Delaware, Lackawanna and Western, the Lehigh Valley, and the Elmira, Cortland and Northern railroads. The University grounds are half a mile from the business center of the city and 400 feet higher, commanding a view of 30 miles of valley and lake. They comprise 270 acres, of which 140 are used by the department of agriculture, and furnish home facilities for clinics and zoötechnics. On the campus of 80 acres are 36 professors' houses, 5 fraternity houses, and over 30 University and College buildings.

The BUILDINGS for the State Veterinary College are seven in number, as follows :



The MAIN BUILDING, 142 feet by 42 feet and three stories high, overlooks East Avenue and an intervening park of 220 feet by 300 feet. The walls are of dull yellowish buff pressed brick, on a base of Gouverneur marble ; window and door facings of Indiana limestone, and terra cotta ornamentation. On the first floor are the museum and rooms of the dean and professor of surgery and obstetrics, and business office (Plate I). The second floor is devoted to the upper part of the museum, a lecture room, a temporary laboratory of Physiology and Pharmacology, reading room, library and rooms of professors (Plate II). The third floor

is devoted to the laboratories of pathology and bacteriology and of microscopy, histology and embryology (Plate III).

Connected with the main building and forming its EAST WING is a structure of 90 feet by 40, and one story high. This contains the anatomical laboratories, and the lecture room of anatomy, medicine and surgery. Its floors are of impermeable cement, the walls lined by enameled white brick, and the ceilings covered with sheet steel (Plate I).

The second extension from the main building is the BOILER AND ENGINE ROOM, where power is generated for heating and ventilation.

The SURGICAL OPERATING THEATRE is a separate building in the rear of the main building, and is furnished with room for forge, instruments, water heater, etc. The lighting and equipment, and the facilities for demonstration, have been specially attended to (Plate I).

The GENERAL PATIENT'S WARD, 100 feet by 31, is furnished with box and other stalls, heating apparatus, baths and all necessary appliances. The floor is of impermeable cement, and the ceilings of painted sheet steel. There is also a fodder room of 20 by 30 feet (Plate VI).

The ISOLATION WARD 54 feet by 15, has its stalls absolutely separated from one another and each opening by its own outer door. It has the usual impermeable floor, with walls of vitrified brick and painted sheet steel ceilings.

The MORTUARY BUILDING has an impermeable floor, walls of enameled brick and painted steel plate ceilings, and is fitted with every convenience for conducting post mortem examinations and preparing pathological specimens.

The SHED 51 by 20 feet, next the operating theatre is devoted to clinical uses.

These, with a cottage for the stud groom, complete the list of State buildings erected for the Veterinary College. The equipment has been made very complete both for educational uses and original research.

For a more detailed account of the equipment and the facilities for instruction see "Departments, methods and facilities," pp. 22–37.

ADMISSION TO THE NEW YORK STATE VETERINARY COLLEGE.

ADMISSION ON CERTIFICATE.

For admission the candidate must possess at least the preliminary education required by the laws of New York (Laws of 1895, Ch. 860). As evidence that the requirements have been fulfilled, the regents issue "Veterinary Student Certificates," and one of these must be filed with the Director of the college.

Briefly stated the legal preliminary educational requirement for admission is that the candidate must have satisfactorily completed a course requiring at least 48 academic, Regents' counts in a registered

academy or high school, or he must have had a preliminary education considered and accepted by the Regents as fully equivalent. A student may be admitted conditionally to a veterinary college who is not deficient in more than 12 of the 48 academic counts, but the deficiency must be made up before beginning the second year of professional study, if that study is to count toward a degree.

The Regents will accept as fully equivalent to the required academic course any one of the following:

1. A baccalaureate degree from the academic department of any college or university of recognized standing.

2. A certificate of having successfully completed at least one full year's course of study in the collegiate department of any college or university, registered by the Regents as maintaining a satisfactory standard.

3. A certificate of having passed in a registered institution examinations equivalent to the full collegiate course of the freshman year or to a completed academic course.

4. Regents' pass cards for any 48 academic counts or any regents' diploma.

5. Certificate of graduation from any registered gymnasium in Germany, Austria or Russia.

6. A certificate of the successful completion of a course of five years in a registered *ginnasio* and three years in a *liceo*.

7. The bachelor's degree in arts or science, or substantial equivalents from any registered institution in France or Spain.

8. Any credential from a registered institution, or from the government in any state or country which represents the completion of a course of study equivalent to graduation from a registered New York high school or academy or from a registered Prussian gymnasium.

(For full information concerning the education necessary to obtain the "Veterinary Student Certificate" or for the acceptance as equivalents of work done in the academies or high schools of this or of other states, not under the Regents, address Examination Department, University of the State of New York, Albany, N. Y.)

ADMISSION ON EXAMINATION.

For the present, students with a "Regents' Veterinary Student Certificate" will be admitted without further examination. For those not possessing such a certificate, admission may be granted to students who pass Cornell University entrance examinations as follows: (The Veterinary College Faculty does not hold entrance examinations. All entrance examinations are given by the Faculty of Arts and Sciences):

The following, representing an equivalent of 24 regents' counts, must be passed by every one trying the examination: (The number of counts each subject represents is given in parenthesis).

English (8). Geography, physical and political (2). Physiology and Hygiene (2). Drawing (2). American History and Civics (2). Plane Geometry (4). Algebra (4).

For an equivalent of the remaining 24 regents' counts the applicant may elect a sufficient number from any combination of the following :

Elementary French (4). Elementary German (4). Advanced French (6). Advanced German (6). Entrance Greek (11). Latin, Cæsar and Grammar (8). Latin, Vergil, Cicero and Composition (7). Physics (4). Chemistry (4). Botany (4). Geology (4). Zoology (4).

The statements below are designed to give an idea of what is expected under each subject.

English: One hour of examination is assigned to answering questions upon the books marked *A*. Two more hours are occupied with writing three essays (250 words each) upon subjects taken from the books marked *B*.

The books prescribed for 1898 are : *A*. Milton, Paradise Lost, Books i and ii ; Pope, Iliad, Books i and xxii ; The Sir Roger de Coverly Papers in the Spectator ; Goldsmith, The Vicar of Wakefield ; Coleridge, The Ancient Mariner ; Southey, Life of Nelson ; Carlyle, Essay on Burns ; Lowell, The Vision of Sir Launfal ; Hawthorne, The House of the Seven Gables. *B*. Shakespeare, Macbeth ; Burke, Conciliation with America ; DeQuincey, Flight of a Tartar Tribe ; Tennyson, The Princess.

For 1899 : *A*. Dryden, Palamon and Arcite ; Pope, Iliad, Books i, vi, xxii, xxiv ; The Sir Roger de Coverly Papers in the Spectator ; Goldsmith, The Vicar of Wakefield ; Coleridge, The Ancient Mariner : DeQuincey, The Flight of a Tartar Tribe ; Cooper, The Last of the Mohicans ; Lowell, The Vision of Sir Launfal ; Hawthorne, The House of the Seven Gables. *B*. Shakespeare, Macbeth ; Milton, Paradise Lost, Books i and ii ; Burke, Conciliation with America ; Carlyle, Essay on Burns.

For 1900 : *A*. Dryden, Palamon and Arcite ; Pope, Iliad, Books, i, vi, xxii, xxiv ; The Sir Roger de Coverly Papers in the Spectator ; Goldsmith, The Vicar of Wakefield ; Scott, Ivanhoe ; DeQuincey, The Flight of a Tartar Tribe ; Cooper, The Last of the Mohicans ; Tennyson, The Princess ; Lowell, The Vision of Sir Launfal. *B*. Shakespeare, Macbeth ; Milton, Paradise Lost, Books i and ii ; Burke, Conciliation with America ; Macaulay, Essays on Milton and on Addison.

The object of the examination is to test the candidate's ability to express himself clearly and correctly ; also, to test his familiarity with the works prescribed.

No candidate markedly deficient in English will be admitted to any course in the University.

Geography, Political and Physical : As much as is contained in the larger school geographies, and in Tarr's "Physical Geography."

Physiology and Hygiene: The equivalent of Martin's "The Human Body" (briefer course), and of Wilder's "Health Notes" and "Emergencies." The treatises of Hutchinson, Huxley, Jenkins, Steeles, and Walker are accepted as equivalents of Martin.

[In the next Register the above list will probably include only the last editions of the secondary and short treatises of Jenkins, Martin, and Wilder, but recent works intended for use in colleges will be accepted as equivalents].

Drawing: To meet the requirement in drawing the student should have had a thorough training of the hand and eye in outline drawing from natural and conventional forms; and he should be master of the principles of perspective and their application in the drawing of geometrical objects. The study of light and shade in models and from nature should be sufficient to enable him to sketch with accuracy and rapidity any of the simple forms and compositions that may be required. As a part of the examination the work of the student, certified by the teacher, should be submitted.

American History with the Elements of Civil Government: It is expected that the study of American History will be such as to show the development and origin of the institutions of our own country; that it will, therefore, include the colonial beginnings; and that it will deal with the period of discovery and early settlement sufficiently to show the relation of peoples on the American continent, and the meaning of the struggle for mastery.

(*The following requirements in Mathematics are the same as those agreed upon by the Conference of representatives from Columbia, Harvard, Pennsylvania, Princeton, Yale and Cornell Universities*).

Plane Geometry: Including the solution of simple original exercises, numerical problems, and questions on the metric system; as much as is contained in the larger American and English text-books.

Algebra: Factors, common divisors and multiples, fractions, equations of the first degree with one or more unknown quantities, involution including the binomial theorem for positive entire exponents, evolution, the doctrine of exponents, radicals and equations involving radicals, quadratic equations of one or two unknown quantities and equations solved like quadratics, ratio and proportion, and putting problems into equations, and including radicals; as much as is contained in the larger American and English text-books.

[In the fundamental operations of Algebra, such as multiplication and division, the management of brackets, the solving of numerical and literal equations of the first and second degrees, the combining and simplifying of fractions and radicals, the interpretation and use of negative quantities and of o and ∞, the putting of problems into equations—the student should have distinct notions of the meaning and the reason of all that he does, and be able to state them clearly in his own

language; he should also be able to perform all these operations, even when somewhat complex, with rapidity, accuracy, and neatness; and to solve practical problems readily and completely. In his preparatory study he is advised to solve a great many problems, and to state and explain the reasons for the steps taken.

In Geometry he should learn the definitions accurately, whether in the language of the text-book or not, and in proving a theorem or solving a problem he should be able to prove every statement made, going back step by step until he rests upon the primary definitions and axioms. He should be able to apply the principles of geometry to practical and numerical examples, to construct his diagrams readily with rule and compass, and to find for himself the solutions of simple problems and the demonstrations of simple theorems. To cultivate this power of origination, he should always, before reading the solution or proof given in his text-book, try to find out one for himself, making use, if necessary, of his author's diagram; and if successful, he should compare critically his own work with his author's and see wherein either is the better. Besides oral recitations, he is advised to write out his demonstrations, having regard both to the matter and to the form of his statements; and when written he should carefully study them to make sure, first, that he has a complete chain of argument, and secondly, that it is so arranged that without defect or redundance one step follows as a logical consequence of another].

Elementary French or Elementary German as below.

(*The following requirements for admission to Cornell University in Elementary French and Elementary German are the same as those agreed upon by the Conference of representatives from Columbia, Harvard, Pennsylvania, Princeton, Yale, and Cornell Universities*).

Elementary French: (a) The translation at sight of ordinary nineteenth century prose. It is important that the passages set be rendered into clear and idiomatic English. It is believed that the power of translating at sight ordinary nineteenth century prose can be acquired by reading not less than four hundred duodecimo pages from the works of at least three different authors. Not more than one-half of this amount ought to be from works of fiction. This number of pages is to include not only prepared work, but all sight reading done in class. (b) The translation from English into French of sentences or of a short connected passage to test the candidate's familiarity with elementary grammar. Elementary grammar is understood to include the conjugations of verbs, of the more frequent irregular verbs, such as aller, envoyer, tenir, pouvoir, voir, vouloir, dire, savoir, faire, and those belonging to the classes represented by ouvrir, dormir, connaître, conduire, and craindre; the forms and positions of personal pronouns, the uses of other pronouns and of possessive, demonstrative, and interrogative adjectives; the inflection of nouns and adjectives for gender and number, except rare cases; the uses of articles, and the partitive constructions.

Pronunciation should be carefully taught and pupils be trained to some extent to hear and understand spoken French. The writing of French from dictation is recommended as a useful exercise.

For examination no specific authors or works are designated. An examination in pronunciation and the writing of French from dictation will be included. All applicants for admission are required to present a statement from their teacher mentioning the text-books used and the authors read, including the number of pages translated from French into English and English into French.

Elementary German: (a) The rudiments of grammar, and especially these topics; The declension of articles, adjectives, pronouns, and such nouns as are readily classified; the conjugation of weak and of the more usual strong verbs; the commoner prepositions; the simpler uses of the modal auxiliaries; the elementary rules of syntax and word order. The proficiency of the applicant may be tested by questions on the above topics and by the translation into German of simple English sentences. (b.) Translation at sight of a passage of easy prose containing no rare words. It is believed that the requisite facility can be acquired by reading not less than two hundred duodecimo pages of simple German.

Practice in pronunciation, in writing German from dictation, and in the use of simple German phrases in the class room is recommended.

For examination no specific authors or works are designated. An examination in pronunciation and the writing of German from dictation may be included. All applicants for admission are required to present a statement from their teacher mentioning the text-books used and the authors read, including the number of pages translated from German into English, and English into German.

In *Advanced French* or *Advanced German:*

(*The following requirements for admission to Cornell University in Advanced French and Advanced German are the same as those agreed upon by the Conference of representatives from Columbia, Harvard, Pennsylvania, Princeton, Yale, and Cornell Universities*).

Advanced French: (a) The translation at sight of standard French. It is important that the passages set be rendered into clear and idiomatic English. It is believed that the necessary proficiency in translation at sight can be acquired by reading, in addition to the elementary work, not less than six hundred duodecimo pages of prose and verse from the writings of at least four standard authors. A considerable part of the amount read should be carefully translated into idiomatic English. (b) The translation into French of a connected passage of English prose. Candidates will be expected to show a thorough knowledge of accidence and familiarity with the essentials of French syntax, especially the uses of tenses, moods, prepositions, and conjunctions. Careful attention should be paid to pronunciation and the uses of spoken French.

For examination no specific authors or works are designated. An examination in pronunciation and the writing of French from dictation will be included. All applicants for admission are required to present a statement from their teacher, mentioning the text-books used and the authors read, including the number of pages translated from French into English and English into French.

Advanced German : (a) More advanced grammar. In addition to a thorough knowledge of accidence, of the elements of word formation, and of the principal uses of prepositions and conjunctions, the candidate must be familiar with the essentials of German syntax, and particularly with the uses of modal auxiliaries and the subjunctive and infinitive moods. The proficiency of the applicant may be tested by questions on these topics, and by the translation into German of easy connected English prose. (b) Translation at sight of ordinary German. It is believed that the requisite facility can be acquired by reading, in addition to the amount mentioned under elementary German (see p. 13), at least five hundred pages of classical and contemporary prose and poetry. It is recommended that not less than one-half of this reading be selected from the works of Lessing, Schiller, and Goethe.

It is recommended that the candidate acquire the ability to follow a recitation conducted in German and to answer in that language questions asked by the instructor.

For examination no specific authors or works are designated. An examination in pronunciation and the writing of German from dictation may be included. All applicants for admission are required to present a statement from their teacher, mentioning the text-books used and the authors read, including the number of pages translated from German into English and English into German.

Greek : candidates are examined on (1) Grammar. A thorough knowledge of the common forms, idioms and constructions and of the general grammatical principles of Attic prose Greek, to be tested by an examination on a prescribed portion of Xenophon (for the next five years Xenophon's Anabasis, Books I and II). The test is to consist in part of questions, in part of simple sentences set for translation into Greek ; it may include also translation from Greek into English. (2) Attic prose at sight. Ability to translate at sight a passage adapted to the proficiency of those who have read not less than 130 Teubner pages of Attic prose. The candidate is expected to show in his translation accurate knowledge of the forms and structure of the language, and an intelligent comprehension of the whole passage. (3) Homer. Ability to translate a passage from some prescribed portion of Homeric poems (for the next three years), Iliad, Book I and Book II, vv. 1–493), and to answer questions designed to test the candidate's understanding of the passage, as well as questions upon poetic forms, constructions, and prosody.

Latin : candidates are examined (1) in the following authors : with questions on subject-matter, constructions, and the formation and in-

flection of words; Vergil, six books of the Æneid, with the prosody; Cicero, six Orations, including the four against Catiline; the translation at sight of passages adapted to the proficiency of candidates who have studied Latin in a systematic course of at least five lessons a week for three years, the passages to be selected from Nepos or Cæsar; and (2) Latin composition based on Bennett's or Jones's Latin Composition.

Physics: Students offering physics for entrance must show an acquaintance with the more important phenomena and with the principles involved in the explanation of them. They must, in addition to a year's work with the text-book, have completed a year of laboratory practice and must be prepared to work simple numerical problems upon the laws of falling bodies; upon the pendulum; upon properties of liquids and gases, including the determination of density; upon thermometry and calorimetry, including specific heats and heats of fusion and liquefaction; upon the relations of current and electromotive force and resistance; upon velocity, wave length and resonance in sound; upon refractive indices, focal lengths and the size and position of images in optics. The student must understand and be able to use the metric system in measurement and computation.

The laboratory work offered must be chiefly quantitative in character, and must consist of at least forty exercises or experiments of the character given in Nichols' "Outlines of Physics," or other works similar to this in grade and method. The laboratory work prescribed above must have been performed by the student individually, in evidence whereof he must present his laboratory notebook at the time of examination. He must, moreover, be prepared to describe intelligently the method pursued and the results obtained in the experiments which he has performed.

Chemistry: Remsen's "Introduction to the Study of Chemistry," or its equivalent, is to be taken as the basis of the examination. In addition to that, laboratory practice must have been taken with the same book as a guide, or some other book of a similar character, representing eighty hours of actual work; the notes upon this, carefully written out, must be presented at the time of the examination, and this record should be endorsed by the teacher at the close of each day's work. Problems in the calculation of gas volumes, and in stoichiometry will be included in the examination. Finally the applicant will be examined on such an amount of qualitative analysis as can be accomplished in eighty hours of actual practice in the laboratory. A carefully written and endorsed note book of this work must also be presented at the time of the examination.

Botany: The student should aim to acquire a knowledge of the general laws and fundamental principles of plant nutrition, assimilation, growth, etc., as exemplified by plants chosen from the different groups, as well as the general comparative morphology and the broader relationships of plants.

The following brief synopsis will suggest the topics and methods of study :

Study protoplasm in plants representing different groups, as spirogyra, mucor, nitella, and in the tissues of some of the higher plants, in order to demonstrate that this substance, though occurring in widely different plants, is fundamentally the same, and reacts in a similar manner to treatment with certain simple reagents.

Study absorption and osmose in plant cells, employing such plants as spirogyra, mucor, the cells of some higher plant as the beet, and in the root hairs of a seedling plant ; test the effect of salt solutions in plasmolyzing the cells of these plants, then the restoration of turgescence in the same cells, and the movement of the protoplasmic membrane to demonstrate the part it plays in the process of absorption in plants.

Study nutrition by comparison of soil and water cultures in seedlings ; study also root pressure ; turgidity in plant parts and cell masses ; transpiration ; the path of movement of liquids in higher plants, and the general structure correlated with these processes ; study nutrition of parasites (carnation rust, dodder), of mushroom.

Study the movement of gases in carbon assimilation as shown by spirogyra, vaucheria, elodaea, etc., in respiration as shown in germinating seeds ; study forms of chlorophyll bodies and the formation of starch, noting the parts of the plant where these processes take place, and using for comparison, spirogyra, zygnema, vaucheria, oedogonium ; liverworts like riccia, marchantia, cephalozia ; mosses like funaria, mnium ; and a few of the higher plants, including lemna.

Study growth of seedlings with reference to increase in length and diameter, direction of growth ; irritability shown by movement of parts in response to stimuli. (The topics as above arranged, as far as possible represent progression of function, and the study of the lower plants throws great light on the processes in the higher forms, and at the same time familiarizes the student with a few of these lower forms).

Study general morphology, reproduction and fruiting in the different groups. Examples are suggested as follows : Among the algae,—spirogyra, vaucheria, oedogonium, coleochatae ; among the fungi,—mucor, saprolegnia, puccinia (wheat rust), one of the erisypheae (powdery mildews), mushrooms ; among the liverworts,—riccia, marchantia, cephalozia ; among the mosses,—funaria, mnium, or polytrichum ; among fern plants,—a fern, equisetum, selaginella, isoetes ; among gymnosperms,—one of the pines ; among angiosperms,—one of the monocotyledons and a dicotyledon. (In this study it will be found useful in dealing with the lower plants to use the same plant as often as possible for the different topics, since fewer new names will be introduced and the student can concentrate the mind upon processes and structures. The plants suggested are chosen for a purpose since they represent pro-

gression of form and structure. The student should study all the stages suggested from the actual material using text-books only as aids).

In the algae, liverworts, mosses and ferns the organs of reproduction can usually be easily studied by beginners if material is preserved at the proper stages in advance, or it may be grown as wanted. In the higher plants the study of the reproductive organs is attended with difficulty. Here and in other difficult topics the studies should be supplemented by demonstrations on the part of the teacher, and by collateral reading.

Study the special morphology of the higher plants by a careful examination of types in the families of angiosperms. The following are suggested,—ranunculaceae, cruciferae, leguminosae, rosaceae, umbelliferae, compositae, labiatae, cupuliferae, salicaceae, liliaceae, araceae, cyperaceae, geraniaceae, orchidaceae.

As a part of the examination, careful notes and drawings must be presented as evidence that the work on the several topics outlined above has been faithfully and successfully accomplished. Those who wish to prepare an herbarium in addition, may present the same as partial evidence, but weight will be given to this only when the herbarium is prepared with a view of illustrating some definite problem either of relationship or of ecological study, as plant distribution in relation to soil, topography of the country, plant formations, etc.

Geology: To meet the requirement in geology it will be necessary to devote at least five periods a week for one year to the study. Of this time not less than two periods a week must be given to laboratory and field work. The text-book used should cover the ground treated in such books as Scott's "Introduction to Geology," Geike's "Class Book of Geology" and Tarr's "Elementary Geology;" but in addition to the subjects included in these books the student will be expected to do collateral reading in such works of reference as Geike's "Text-book of Geology," Dana's "Manual of Geology," Lyell's "Principles of Geology" and LeConte's "Elements of Geology." It would also be well to refer to books on specific subjects, such as Dana's "Characteristics of Volcanoes," Dana's "Corals and Coral Islands," Russell's "Volcanoes," Russell's "Lakes," Wright's "Ice Age in North America," Russell's "Glaciers," etc. The examination will test not merely the knowledge upon the text-book itself, but also the range and thoroughness of the work done with reference books. Carefully written digests of the parts read in the reference books, if certified by the teacher, may be offered in evidence of the amount of work done with them.

Much stress will be placed upon that part of the examination testing the laboratory and field work. This will consist in part of the notes upon that work, certified by the teacher. This laboratory and field work should in large measure be made a study of the home geology; and evidence of good work in this connection will be necessary in order to pass the subject.

In the laboratory the common minerals and rocks should be studied so that the pupil may identify them without difficulty. Photographs of geological phenomena should also be studied, and training be given in the interpretation of geological maps. An elementary knowledge of paleontology should be obtained by the study of some of the common fossils; and if the school is situated in a fossiliferous region, field work in stratigraphic geology should be included, together with the collection of fossils and their identification in the laboratory. Some hints concerning the nature of the work expected in the laboratory and the field may be gained from Tarr's "Suggestions for Laboratory and Field Work in High School Geology."

Zoology: The examination in zoology will consist of two parts as follows:

I. *Invertebrate Zoology:* The candidate must have devoted the equivalent of five periods a week for at least one half year to the study of invertebrate zoology; and the greater part of this work must have been laboratory practice in the observation of living forms and in dissection. His laboratory notes and drawings endorsed by the teacher will be required at the time of the examination as evidence of the nature of this part of the work. This laboratory practice should include a study of at least thirteen of the forms named in the following list: amœba, paramœcium, hydra, sea-anemone, star-fish, sea-urchin, earthworm, cray-fish, lobster, spider, millipede, centipede, locust (grasshopper), dragon-fly, squash-bug, butterfly, bumblebee, clam, snail, and squid.

The laboratory work must be of the character given in Needham's "Elementary Lessons in Zoology," Colton's "Practical Zoology," or other works similar to these in grade and method. In addition to the above books, the student should have access to some advanced work like Parker and Haswell's "Text-book of Zoology," for reference.

The examination will call for a discussion of the habitat, mode of life, and post-embryonic development (transformations) as well as of the morphology of the forms studied.

II. *Vertebrate Zoology:* To meet the requirement there should be submitted drawings and notes in evidence of the dissection of the viscera of forms representing groups as follows:—Mammals (cat, dog, monkey, rabbit, rat or opossum); Birds (common fowl, pigeon, or other convenient form); Reptile (serpent, and either a turtle or an alligator); Batrachian (salamander, toad or frog, and a tadpole); "Fishes" (sturgeon, amia or gar; cat-fish, sucker, carp or other soft rayed fish; bass, perch or other spiny rayed fish; shark or ray; lamprey or hag; lancelet (amphioxus), and a simple tunicate, i. e., boltenia or molgula).

Particular attention should be paid to the brain, the heart and the respiratory apparatus. The muscles of the arm and leg should be dissected upon a mammal, a bird, and a reptile, and the differences pointed out. There must be prepared a skeleton (which need not be mounted) of

a mammal, bird or fish; and skulls of at least five other vertebrates. (In preparing these skulls remember that the hyoid goes with the skull). The skulls, with proper labels, must be submitted at the examination.

Two mammals should be compared in respect to their habits, food, mode of locomotion, etc.; likewise two birds, two reptiles, two batrachians, and two "fish."

Besides the practical work above indicated, the student must gain from lectures or from text-books designed for high schools or colleges (e. g., Parker & Haswell's "Text-book of Zoology," 1897), a comprehensive knowledge of the members of the classes or groups represented by the forms studied as described above. This knowledge must include their geographical distribution, habits and relation to human beings, whether beneficial or injurious, directly or indirectly; the relations of the young to the parent in respect to oviparity and viviparity and the exceptions to the general rules; the form and structure of the red blood corpuscles and the exceptions to the general rules. In case some point of information in your note-book is derived from a text-book or a cyclopaedia, give an exact reference to the source of the information.

ADMISSION TO ADVANCED STANDING.—Applicants for admission to advanced standing as members of the 2d or 3d year class must present the necessary educational qualifications for admission to the first year class (see p. 8) and must pass a satisfactory examination in all the work gone over, or offer satisfactory certificates of the completion of such work in other veterinary schools whose entrance requirements and courses of study are equivalent to those of this college. No person will be admitted to any advanced class except at the beginning of the college year in September.

Applicants for advanced standing from other veterinary colleges must send or present letters of honorable dismissal, and furnish the Director, Dr. James Law, with a catalog containing the courses of instruction in the institution from which they come with a duly certified statement of the studies pursued and their proficiency therein, and also a statement of the entrance requirements with the rank gained. To avoid delay these credentials should be forwarded at an early date in order that the status of applicants may be determined and information furnished concerning the class to which they are likely to be admitted.

Graduates of veterinary colleges whose requirements for graduation are not equal to those of the New York State Veterinary College may be admitted provisionally upon such terms as the faculty may deem equitable in each case, regard being had to the applicant's previous course of study and attainments. In this connection, attention is called to the legal requirements of academic and professional education for the practice of Veterinary Medicine in the State of New York. (See pp. 8, 41, and Appendix B).

ADMISSION TO GRADUATE WORK.—The ample facilities for graduate work in the New York State Veterinary College, with allied departments in Cornell University, are open to graduates of this institution and of other Veterinary Colleges whose entrance requirements and undergraduate courses are equivalent. (See pp. 8, 20).

RESIDENCE AND REGISTRATION.

Residence in Ithaca is required of all students. For leave of absence during term time application should be made to the Director, Professor Law.

Registration—At the beginning of each term (see calendar for exact day and date) the student must register with the University Registrar, Room 9 A, Morrill Hall. After registering with the University Registrar, he must, on the same day, register with the Secretary of the Faculty, Dr. Fish, Room 11, 2d floor, of the Veterinary College.

REQUIREMENTS FOR GRADUATION.

In order to receive the degree of Doctor of Veterinary Medicine (D.V.M.) the candidate must satisfy all the entrance requirements (pp. 8–9) and successfully pursue the courses named in the schedule of studies given below.

The thesis required in the last year (see schedule) is designed to give the student opportunity to investigate some subject in which he has become particularly interested, and to give him training in presenting the results of the investigation in proper literary form.

A final examination upon all subjects pursued during the entire course will be given during the last week of the third term to all candidates for degrees. (In 1898-99 this examination will occur Tuesday and Wednesday, June 6, 7, 1898).

SCHEDULE OF THE COURSES LEADING TO THE DEGREE OF DOCTOR OF VETERINARY MEDICINE.*

First Year.	1st Term.	2d Term.	3d Term.
Inorganic Chemistry	3. T. or Th., 12	3. T. or Th., 12	3. T. or Th., 12
Anatomy	2. T., Th., 9	2. T., Th., 9	2. T., Th., 9
Dissection	4.	4.	4.
Microscopy and Histology	2. M., W., 8	2. M., W., 8	–
Laboratory	3.	3.	–
Embryology	–	–	3. M., W., F., 8
Laboratory	–	–	2.
Comparative Physiology	1. F., 10	1. F., 10	1. F., 10
Breeds and Breeding	2. M., W., 12	2. M., W., 12	2. M., W., 12

Second Year.	1st Term.	2d Term.	3d Term.
Organic and Physiological Chemistry	2.	2.	2.
Anatomy	1. W., 9	1. W., 9	1. W., 9
Dissection	4.	4.	4.
Comparative Physiology	1. W., 10	1. W., 10	–
Laboratory	2.	–	–
Pharmacology	1. M., 10	1. M., 10	1. M., 10
Pharmacy	–	2.	–
Therapeutics	–	–	1. W., 10
Medicine	3. M., W., F., 8	3. M , W., F., 8	3. M., W., F., 8
Surgery	5. M., T., W., Th., F., 11	3. M., W., F., 11	–
Obstetrics	–	2. T., Th., 11	4. T., W., Th., F., 11
Jurisprudence	–	–	1. M., 11
Sanitary Science or Parasitism	2. T., Th., 8	2. T., Th., 8	2. T., Th., 8
Bacteriology	1. M., 9	1. M., 9	1. M., 9
Laboratory	2.	2.	2.
Clinics, medicine and surgery	3.	3.	3.

Third Year.	1st Term.	2d Term.	3d Term.
Medicine	3. M., W., F., 8	3. M., W., F., 8	3. M., W., F., 8
Clinics, medicine and surgery	6,	6.	6.
Surgery	5. M., T., W., Th., F., 11	3. M., W., F., 11	5. M., T., W., Th., F., 11
Zootechnics	–	2. T., Th., 11	–
Toxicology	–	2.	–
Parasitism or Sanitary Science	2. T., Th. 8	2. T., Th., 8	2. T., Th., 8
Pathology	2. T., Th., 9	1. T., 9	–
Laboratory	–	1.	–
Meat Inspection	–	–	1. T., 9
Laboratory	–	–	1.
Research and Thesis	3.	3.	3.

*If the hours for lectures, etc., are not given in the schedule, the time will be arranged with the class.

DEPARTMENTS, METHODS AND FACILITIES.

In addition to the departments of the Veterinary College proper; the resources of the entire University are practically at the disposal of the college by the action of the board of trustees at the time when authorization was given for its location on the campus of the Cornell University (p. 5, under foundation). Among the facilities of the university of especial value to the veterinary college may be mentioned the museums of Vertebrate and Invertebrate Zoölogy including Entomology, of Agriculture, of Botany and of Geology. The Magnificent University Library, with its 200,000 bound volumes, 34,000 pamphlets and 600 current periodicals and transactions, is likewise as freely open to veterinary college students as to other university students (see also Veterinary Library, p. 37).

The Departments, with their special equipment facilities and methods, are given in the order in which the subjects are pursued in the course.

The Courses Required for Graduation are given in the schedule of studies, p 21, but the additional courses offered by the various departments are thought to be of especial value to veterinary students and may be elected by them whenever they have satisfied the requirements.

In all laboratory Courses and clinics two and one-half (2½) actual hours of laboratory practice are required for each hour of credit; e. g., for a three hour laboratory course, 7½ actual hours of laboratory work are required each week.

CHEMISTRY.

The instruction in chemistry is given in the university chemical building, Morse Hall (plate VII). This building is used solely for chemistry and is fully equipped with modern apparatus and material. The laboratories furnish the most ample accommodation for practical work, and the lectures are fully illustrated by specimens, demonstrations and lantern views. The chemical library, in the building and accessible to students, contains complete sets of all important journals, and is very fully supplied with works of reference and standard books on chemistry and allied subjects.

For a full account of the department with its 39 courses, one may consult the University Register or the special announcement of the chemical department (see 3d page of cover).

COURSES.

These are the courses pursued by veterinary students and must be taken in the order here indicated.

1. Elementary, general inorganic chemistry. Three hours weekly throughout the year. This consists of one lecture (T. or Th. 12), one recitation and one hour of laboratory work. Professors CALDWELL and TREVOR and Instructor KORTRIGHT.

20. Organic chemistry. Fall term. Two hours. (Time to be arranged with the class). Professor ORNDORFF.

45. Physiological chemistry. Winter and spring terms. Two hours. (Time to be arranged with the class). Professor ORNDORFF.

ANATOMY.

The instruction in anatomy is by lectures, recitations and laboratory work, the latter being by far the most important. The objects of the lectures are to present facts of general morphology as related to the horse and other domestic animals; to direct attention, as far as possible, to the correlation of structure and function of the various organs of the body and to emphasize the anatomical relations of those parts most subject to surgical operations. The main reliance, however, is placed upon the work done in the laboratory. Thorough practical knowledge of anatomy can be acquired in no other way, and every student will be required to dissect all the parts of the horse, or ox, and such other of the domestic animals as may prove most expedient, before taking his final examinations.

The courses in anatomy extend through two years. The first year is devoted to the study of the bones, joints, muscles and certain of the viscera; the second year, to the vascular and nervous systems and the organs of special sense.

In the study of the osseous and muscular systems, the skeletons in the laboratory, and the Auzoux models afford valuable assistance. In the museum there are accumulating series of specimens which illustrate, in a typical manner, some of the more important anatomical features of the various domestic animals.

The department of anatomy occupies the whole of the east wing—a structure 90 feet by 40 feet and one story in height (Plate I). The floors are of impermeable cement; the walls are lined by enameled white brick and the ceilings covered with sheet steel. The main laboratory is 54 feet by 40 and 22 feet in height. It is well lighted by skylights and by electricity. It is heated by steam and hot air. The ventilation is nearly perfect, fresh air being forced into the room by large fans situated in the basement. The entire volume of air in the laboratory can be changed every 5 minutes without creating any perceptible draft. This constant supply of abundance of pure air is an especially important feature in a dissecting room. The laboratory is supplied with mounted skeletons and other osteological material, a large refrigerator, set of

Fairbanks scales, weighing either kilograms or pounds, injecting and other laboratory apparatus.

In addition to the general libraries of the University and of the college, (p. 37) there are upon the book shelves, in the laboratory, dictionaries, both English and medical, a complete set of the Reference Handbook of the Medical Sciences, standard text-books of anatomy, physiology, physics, etc., for the special use of the students in the laboratory, as books of reference.

Connected with the main laboratory is a similar one, 22 feet by 22, which is used as a preparation room and as a private laboratory (Plate I).

Opening into the laboratories is a locker room, containing lockers for the accommodation of 150 students, and off from this room are the lavatories, etc. (Plate I).

The city and surrounding country furnish any quantity of anatomical material, and in almost endless variety; horse, ox, sheep and swine, dog, cat, rabbit and guinea-pig, both adult and in all stages of fetal development.

The facilities for the study of anatomy are limited only by lack of preparation and time, on the part of the student.

After finishing the required work, students are encouraged to undertake some piece of original work, in either comparative or surgical anatomy.

COURSES.

Of the following courses, the two first are required of the veterinary students; the others are general courses:

1. General and descriptive veterinary anatomy. Fall, winter and spring. Six hours. Two lectures and laboratory work. T., Th., 9 Dr. HOPKINS and demonstrators.

2. Descriptive veterinary anatomy. Fall, winter and spring. Five hours. One lecture and laboratory work. W., 9. Dr. HOPKINS and demonstrators.

This course must be preceded by course 1.

3. Anatomical methods and gross anatomy. Fall term. Three hours. One lecture and laboratory work. S. 12. Dr. HOPKINS.

4. Advanced anatomy. Winter term. Three hours. One lecture and laboratory work. S., 12. Dr. HOPKINS.

Course 4 must be preceded by course 3 or its equivalent.

5. Human anatomy. Laboratory work throughout the year. Dr. HOPKINS.

This course is open to those who have had one or more of the preceding courses.

6. Research and thesis. Three hours throughout the year. Dr. HOPKINS.

COMPARATIVE PHYSIOLOGY.

It is the aim of this department to select from a wide field of interesting topics, those which will be of greatest use to the student, in preparation for a more complete understanding of *normal* functions, as distinguished from the pathological changes so frequently encountered in the practice of human and veterinary medicine.

The fact that it is essential to know the natural before undertaking the diagnosis of unnatural conditions is thoroughly emphasized.

The lectures are supplemented as fully as possible by diagrams, preparations and experiments.

In additon to the didactic instruction a course in the laboratory is provided, which is intended to supplement and extend the lecture courses. The laboratory of comparative physiology is located, for the present, upon the second floor of the main building (Plate II). It is well lighted and equipped with necessary reagents and apparatus, additions to which are made as needed. Students are rendered every assistance in the comprehension of the fundamental parts of their work without, however, losing sight of the fact that careful observation and self-interpretation are most essential for a proper scientific training. Every encouragement is offered, to those properly fitted, to pursue their work beyond that given in the regular course. As a part of the equipment may be mentioned a kymograph, sphygmograph, induction coil and various batteries, a centrifuge and other apparatus for urinalysis.

To those intending to be teachers, as well as those contemplating the study of human or veterinary medicine, the course will be especially useful as it deals with experiments on the functional changes going on in the human and animal body, the exposition of which, is none the less important because, in many cases, of an elementary nature.

COURSES.

1. Required of the first year veterinary students, and treats of the digestive functions, circulation, respiration, and excretion. The work given in this course precedes quite logically that of Pharmacology and Therapeutics. Lectures, one hour each week through the year. F., 10. Dr. FISH.

2. The functions of the muscular and nervous systems and reproduction are considered in this course, which is a direct continuation of course one. Lectures one hour each week through the fall and winter terms. W., 10. Dr. FISH.

3. Practical work in the laboratory. A large proportion of the work is devoted to the digestive system. Artificial digestive juices are tested upon the various kinds of foods by the student and careful notes kept of the various processes. Those who can devote more than the required time are taught how to make the various digestive extracts. A course in urinalysis is also required in order that students may familiarize them-

selves with some of the more common but important changes occurring during health and disease. Experiments in blood pressure and upon the muscular and nervous systems will be carried on as time and opportunity permit. Fall term. Two hours. M., 2–5, W., 2–4. Dr. FISH.

4. Research and Thesis. Three hours throughout the year. Dr. FISH.

MICROSCOPY, HISTOLOGY AND EMBRYOLOGY.

As indicated by the following courses, this department offers elementary and advanced instruction in the theory and use of the microscope and its accessories, in photo-micrography, in vertebrate histology, and vertebrate embryology; and opportunities for research in all of these subjects.

The rooms for the use of this department are on the third floor, and as shown by the plan (Plates III, V), they are ample and almost perfectly lighted. They consist of a large general laboratory, a research laboratory and the private laboratory of the professor in charge where special demonstrations of difficult subjects are given to small groups of students.

The material equipment consists of a good supply of modern microscopes each one of which is fitted with a low and medium power dry objective and a 2 mm. homogeneous immersion objective. Camera lucidas, polariscopes, micro-spectroscopes, photo-micrographic cameras, and other special apparatus are in sufficient numbers to give each student opportunity for personally learning to use them, and for applying them to any special study in which they are called for. The general and research laboratories are large, and are equipped with microtomes, incubators, aquariums, etc. The collection of histologic and embryologic specimens is extensive and constantly increasing. Full sets of typical specimens are available for study and comparison by the students.

The aim of the department is to bring the student into direct contact with the truths of nature, and hence, while there are lectures to give broad and general views, there is a large amount of laboratory work in which the facts are learned at first hand, and the methods and manipulations necessary for acquiring the facts are practiced by each student. It is recognized that less ground can be covered in a given time in this way, but it is believed, and experience has confirmed the belief, that the intellectual independence and the power to acquire knowledge direct from nature which is gained by this personal work, is of far higher value than the facts and theories that might be learned in the same time from books and lectures alone, or from specimens prepared by some other individual.

This lake region with its rich and varied fauna is especially favorable for investigations in the histology and embryology of all the main groups of vertebrates and the proximity of the abattoirs in the city makes it possible to obtain abundant material for the study of the development of

the sheep, cow and pig. The college clinic and the department of anatomy supply an abundance of material for the embryology of the cat and dog so that the opportunities for research upon the development of the domestic animals are excellent. Every encouragement is given for the fullest utilization of these opportunities by students in the preparation of theses and for special investigations.

COURSES.

1. The Microscope and Microscopical Methods. First half of fall term. Two hours. Two lectures and three hours of laboratory work. This course forms the basis for all the subsequent work given by the department. It is also designed to give a knowledge of the theory and use of the microscope and its accessories which would be advantageous for the work of any department where the microscope is employed. M., W., 8. Professor GAGE and Instructor KINGSBURY.

This course counts for two hours for the term, although the work must all be done in the first five weeks.

2. Vetebrate Histology. Last half of fall term (3 hours) and the winter term (5 hours). Eight hours. Two lectures and three hours laboratory work. In this course are given the elements of the fine anatomy of the domestic animals and of man. It includes also methods of histological investigation and demonstration. M., W., 8. Professor GAGE and Instructor KINGSBURY.

This is a continuation of course 1 and is open only to those who have taken course 1, and have taken or are taking courses in anatomy and physiology.

3. Vertebrate Embryology. Spring term. Five hours. Three lectures and two hours of laboratory work. This course deals with the elements and methods of embryology in man, the domestic animals and the amphibia. M., W., F., 8. Professor GAGE and Instructor KINGSBURY.

Course 3 is open only to those who have pursued courses 1 and 2. (The lectures alone may be attended by those who have taken courses 1 and 2 in Physiology and Vertebrate Zoology).

4. Research in Histology and Embryology. Laboratory work with Seminary throughout the year. This course is designed for those preparing theses for the baccalaureate or advanced degrees and for those wishing to undertake special investigations in histology and embryology. Professor GAGE and Instructor KINGSBURY.

Course 4 is open only to those who have taken courses 1, 2 and 3, or their equivalent in some other University. Drawing (course 9, in Mechanical Engineering, or its equivalent) and a reading knowledge of French and German are indispensable for the most successful work in this course.

Subjects for baccalaureate theses should be decided upon if possible during the spring term of the junior year so that material in suitable stages of development and physiologic activity may be prepared.

5. Structure and Physiology of the Cell. Spring term. Two hours. Laboratory work with lectures. This course is designed for advanced students who wish to investigate cytologic problems. Dr. KINGSBURY.

6. Advanced Microscopy. Spring Term. Two hours. Laboratory work with lectures. In this course special instruction will be given in the theory and use of the more difficult and important accessories of the microscope, *e. g.*, the micro-spectroscope, the micro-polariscope, the apertometer, the photo-micrographic camera and the projection microscope. Professor GAGE.

This course is open only to those who have taken course 1, and if photo-micrography is desired, an elementary knowledge of photography like that given in course 9, Department of Physics, is ncecessary.

7. Seminary. There will be a meeting of the department staff and students engaged in research, once in two weeks, for conference and report upon special investigations. (See Veterinary College Seminary, p. 38).

NOTE.—For the work of this department, the student will find a knowledge of Latin and Greek of the greatest advantage. A year's study of Latin, three to five recitations per week, and of Greek, Goodell's Greek in English, or Coy's Greek for beginners, would represent the minimum amount needed. For all courses, the ability to draw well free hand, and a good reading knowledge of French and German are desirable, and for research work almost indispensable.

THE COLLEGE OF AGRICULTURE—BREEDS AND BREEDING.

The College of Agriculture comprises the Departments of General Agriculture ; Animal Industry and Dairy Husbandry (Plate VIII.); Horticulture and Pomology ; Agricultural Chemistry ; General and Economic Entomology and the Agricultural Experiment Station.

The University grounds consist of 270 acres of land, bounded on the north and south by Fall Creek Ravine and Cascadilla gorge respectively. One hundred and twenty-five acres of the arable land are devoted to the use of the Agricultural Department. This part of the domain is managed with a view not only to profit, but also to illustrate the best methods of general agriculture. A four years' rotation is practiced on the principal fields ; one year of clover, one of corn, one of oats or barley, and one of wheat. A dairy of twenty cows, a flock of sheep, some fifteen horses and colts, and other livestock are kept upon the farm. Nearly all of these animals are grades, bred and reared with the single view of giving object lessons which can be practiced with profit by the students on their return to their homes. A four story barn provides for housing all the animals, machinery, tools, hay, grain, and manures. The stationary thresher, feed-cutter, chaffer, and other machinery are driven by steam power. The barn also furnishes many facilities for carrying on investigations in feeding and rearing all classes of domestic animals.

The barn is also furnished with a well equipped piggery and tool house. Not far from the main barn have been constructed four buildings with suitable yards and appliances for incubating and rearing domestic fowls.

The agricultural class room is provided with a collection of grains and grasses, implements of horse and hand culture, and various appliances for carrying on instruction and conducting investigations. The whole plant is managed with a view to the greatest economy consistent with the greatest efficiency in imparting instruction.

COURSES.

The courses in the college attended by veterinary students are given by the department of Agriculture proper and are as follows :

3 (in part). The horse, breeds and breeding, feeding, education, care and driving. Fall term. Two hours. M. W. 12. Professor ROBERTS.

10. Animal Industry. Principles of breeding, history and development, improvement and creation of dairy and beef breeds of cattle (Plate VIII); principles of feeding, care, selection and management of dairy and beef cattle. Winter and spring terms. Two hours. Practice, one hour by appointment, for those electing it. M. W. 12. Assistant Professor WING.

PHARMACOLOGY.

(Plate II.)

The term is employed in its comprehensive meaning to include not only the materials of medicine, but their preparation, use and physiological action. Allowing for certain exceptional differences, there is, in general, a great resemblance in the action of drugs in the lower animals and human beings. The efficiency of new drugs is commonly tested upon the lower forms before being applied to man. For a broad and enlightened human practice a medical course dealing with the treatment of lower animals offers a most advantageous preparation.

The more important drugs and preparations as given in the U. S. Pharmacopœia are studied, including the new ones which appear from time to time.

The clinics furnish abundant material for the use of medicines and the study of their actions.

The physiological changes in certain tissues resulting from the toxic doses of many drugs are as yet unknown, and opportunities for research are abundant in this field.

COURSES.

1. The Materials of Medicine. A study of the uses and actions of the various drugs and their preparation. A varied collection of the crude drugs is available and examined at the recitations. The course is con-

ducted in the form of lectures and frequent examinations. One hour each week throughout the year. M., 10. Dr. FISH.

2. Pharmacy. Each student is required to make those preparations which are most commonly used in practice; tinctures, fluid extracts, balls, powders, ointments, etc. In addition to this each student will have practical experience in writing and compounding prescriptions. The importance of a discriminating and accurate system for dispensing medicines is kept well in mind. Two hours per week. Winter term. M., 2–5, W., 2–4. Dr. FISH.

3. Therapeutics. The treatment and cure of disease. This subject, standing along with pathology, unites physiology, anatomy, chemistry, and botany with medicine and surgery. It is therefore desirable to have some knowledge of these branches in order to obtain a full appreciation of the means employed in the restoration of health. Lectures one hour each week. Spring term. W., 10. Dr. FISH.

This course must be preceded by the first year course in physiology, or its equivalent.

4. Research and Thesis. Three hours throughout the year. Dr. FISH.

VETERINARY MEDICINE; ZYMOTIC DISEASES, VETERINARY SANITARY SCIENCE; PARASITES AND PARASITISM.

The course in Veterinary Medicine deals with the purely medical diseases of the different genera of domestic animals,—including the various constitutional, dietetic and toxic affections and the maladies of the different systems of organs—digestive, respiratory, circulatory, urinary, cutaneous, nervous and visual. The lectures and recitations extend over the two last years of undergraduate study. They are illustrated by diagrams, by dry and wet museum specimens and by subjects presented in the clinics. The special value of the course lies in its wide scope which includes equally all species, the aim being not to make students hippopathologists only, but zoöpathologists or more definitely veterinary pathologists. The site of the College between the city of Ithaca and a well stocked agricultural environment is well calculated to carry out this aim.

In course 2 is treated the general subject of zymosis and contagion; the microbiology of diseases; the accessory causes such as special conditions of soil, culture, climate, season, weather, trade, migration, war, consumption of animal food, etc.; the diagnosis of the different plagues, the various methods of control and suppression by the individual owner, the municipality, town, county, state, or nation; and the exclusion of pestilences from a country. Each zymotic disease is made a special study, and its transmissibility to different genera of animals, from animals to man, and from man to animals together with the susceptibitity of each genus to immunization and the best known means of securing this receive due attention. Enzoötic affections receive the same attention, and the necessary preventive measures in connection with soils, drainage, build-

ings, exposures, wells, ponds, marshes, factories and other local causes are fully dealt with. Illustrative diagrams, preserved specimens and, when opportunity offers, fresh subjects and specimens are employed for demonstration.

In the course on parasites and parasitism, the zoölogical place of the parasite in nature, its life history in connection with the animal body and apart from it, the lesions and symptoms caused, the genera susceptible, and its diagnosis, destruction and prevention are fully considered. An extensive collection of the parasites of domestic animals is available for demonstration, and where these are lacking, diagrams and illustrations will be used.

The medical clinic covering this whole field, and drawn from city and country alike, furnishes the greatest possible variety as regards genus and species of patient, while the hospital and isolation wards furnish a supply of cases that can be watched from day to day. Individual cases are placed in charge of senior students who keep a record of symptoms and treatment. This record is open to the entire class so that all can profit equally by every case. Outpatients on the University farm and in the city can also be availed of for clinical uses.

COURSES.

1. Veterinary Medicine: Principles and Practice. Fall, winter and spring. Three hours. M., W., F., 8. Professor LAW.

This course extends over two years.

2. Contagious Diseases; Veterinary Sanitary Science. Fall, winter and spring. Two hours. T., Th., 8. Professor LAW.

[This course will be given to second and third year men in 1898–99. See the following]:

3. Parasites and Parasitic Diseases. Fall, winter and spring. Two hours. T., Th., 8. Professor LAW.

[This course will be given to second and third year men in 1899–1900. See the preceding].

4. Clinical Veterinary Medicine; second year men. Fall, winter and spring. Three hours. Professor LAW.

5. Clinical Veterinary Medicine; third year men. Fall, winter and spring. Six hours. Professor LAW.

6. Research and Thesis. Three hours throughout the year. Professor LAW.

SURGERY, OBSTETRICS, ZOÖTECHNICS AND JURISPRUDENCE.

SURGERY.

The instruction in Surgery is designed to equip the student with both theoretical and practical knowledge thorough in every respect.

The class room work extends through the second and third years and consists of lectures, or of recitations supplemented by lectures.

One term of fourteen weeks, five hours per week is given to General Surgery, including general surgical pathology, the infection of wounds, surgical therapeutics, aseptic and anti-septic treatment of wounds, the handling and restraint of animals.

Special Surgery extends over the remainder of the course, considering in detail the surgical disease of the various parts of the body, their causes, nature, diagnosis and treatment, to which is added an extended course in castration and spaying. The facilities for the instruction are in keeping with the general aim and scope of the college.

Abundant instruments and apparatus of both home and foreign patterns are provided for illustrating the lectures; while the college museum contains abundant material which is freely used for exemplifying surgical pathology.

The college becomes the possessor of the extensive pathological collection of the veterinary department of Cornell University, accumulated during nearly thirty years, to which have been added many valuable preparations contributed by veterinarians, and secured from the college clinics.

The course in practical surgery extending through the second and third years is given in the college clinics.

The location of Cornell University and the organization of the Veterinary College gives unusual opportunities for clinical instruction in the number and character of cases, the variety of species of animals and the availability of each case for purposes of instruction.

As each member of the veterinary faculty is exclusively employed by the college and is in no degree dependent upon private practice, all reasonable effort is exercised to lead owners of livestock to enter cases in the free clinics instead of diverting special cases to private practice.

The college clinics being wholly free, regardless of the value of the animal, the severity of the proposed operation or the owner's ability or willingness to pay, obviates the usual disadvantages of free clinics where largely inferior animals the property of poor and frequently careless people are presented in a state of health and with general surroundings not propitious for testing the value of a line of treatment or of following it to a successful issue, failing consequently to impart the desired knowledge, interest or enthusiasm to the student; while in our free clinics the student has to deal with animals of the same general character and value as those met with in ordinary veterinary practice.

The thickly inhabited agricultural country about Ithaca furnishes an abundance of clinical material of all classes of disease not alone of horses and dogs but of every species of domesticated animals.

Numerous cases, especially those for major surgical operations, are drawn from a radius of twenty-five miles thus placing a large and important stock-producing area tributary to our clinics.

All patients are admitted subject to our discretion as to whether an operation shall be performed by a member of the staff or by a student, the general plan being for the professor in charge to perform a sufficient number of operations to illustrate methods in a given case, after which they are performed by students in turn, under immediate supervision, aiming in this way to thoroughly fit men to perform any desired operation supported by that skill and confidence which actual work alone can give.

Practical Surgery is required of all second and third year students, the course extending through both years.

The second year student devotes three hours per week to clinics throughout the year, during which period he is required to keep in order and sterilize operating instruments, apply dressings to wounds, prepare and apply plaster of Paris and other fixation bandages to various parts, and to perform such surgical operations as opening abscesses, excising simple tumors and controlling the consequent hemorrhage, castration and spaying of dogs and cats, castration of normal horses, rasping, cutting and extracting irregular teeth and other operations of a similar grade.

The third year student devotes six hours a week throughout the year to clinics, repeats and perfects himself in the operations of the second year, makes examinations and diagnoses, administers chloroform to the larger animals and personally performs the major surgical operations, such as the removal of extensive tumors, the more difficult cases of dental surgery, ovariotomy in mares and cows, arytenectomy, tenotomy and other operations of a similar class. This work is carefully graded and the student advanced as rapidly from the simpler to the more difficult operations as is consistent. While the cadaver is used as needed for demonstrating surgical anatomy and procedure it is the policy of the department to require the student to perform the operations upon living animals of commercial value and for curative purposes.

Each student must acquire practical and experimental knowledge of surgery parallel to his theoretical training in the class room and is required to demonstrate his ability in the operating theatre.

All patients upon which important operations are performed are detained in the surgical ward until the crisis of the operation has been passed, and the student operating is required to follow his work and is held personally responsible for the proper after treatment of his patient.

All needed instruments and appliances for instruction in practical surgery are provided, while the surgical ward and operating room elsewhere described are commodious and perfect in every appointment. The most modern appliances for securing and controlling animals such as operating tables, stocks and casting apparatus are fully provided (Plate VI).

Special investigations in relation to surgical diagnosis, pathology and treatment are constantly being carried on, the material for such

work being abundant. Special apparatus for investigations is supplied as needed, and advanced students are called upon to actively assist in the various investigations, becoming not only more familiar with surgical manipulations but inspired to study methodically and effectively the many questions in surgical pathology and therapeutics, and thus become better prepared to cope promptly and properly with the many atypical cases constantly occurring in general practice.

OBSTETRICS.

A thorough course of obstetrics is given during the second year, consisting chiefly of lectures including two hours per week during the winter term and four hours per week in the spring term.

The course is preceded by an extended study of embryology during the first year which serves as a foundation for the proper consideration of the subject. Obstetric anatomy and physiology have also been in a measure mastered during the first year in the departments of anatomy and physiology ; all three are then reviewed with special reference to obstetrics, teratology, and diseases of new-born animals.

The lectures are based in arrangement on Fleming's obstetrics supplemented by personal experience. Models and valuable museum preparations are used for illustration. While our location permits of the securing of much valuable clinical material, such obstetric cases as can not be brought to the college clinic are attended at the owner's premises by the class, under the personal direction of the professor in charge ; the students are in this way brought into actual contact with a class of cases the proper handling of which can not otherwise be effectively taught.

ZOÖTECHNICS.

The subject of Zoötechnics is chiefly taught in the College of Agriculture of Cornell University, covering the various breeds of domestic animals, the methods of breeding and handling.

Supplementary to this instruction a course of lectures covering one term two hours a week will be given dealing especially with the breeding, care and management of animals in relation to disease, hereditary diseases and vices and a general resumé of the subject of breeding as related to veterinary science.

JURISPRUDENCE.

A course of two lectures a week is given during the winter term of the second year, dealing with the general responsibilities of veterinarians to the public, to stock owners and professional colleagues ; methods of making and recording examinations for soundness, and a special study of physical diagnosis and prognosis as related to this subject.

Practice is given from time to time in the work at the clinics.

COURSES.

Students are not admitted to the third year in Surgery unless they have completed courses 1 and 2 in physiology, anatomy and histology.

1. General Veterinary Surgery. Fall term. Five hours. M., T., W., Th., F., 11. Professor WILLIAMS.

Course 1 is open only to those who have completed courses 1 and 2 in histology and course 1 in physiology.

2. Special Surgery (head and neck). Winter. Three hours. M., W., F., 11. Professor WILLIAMS.

Course 2 is open only to those students who have completed course 1 in anatomy, physiology and histology.

3. Veterinary Obstetrics. Winter. Two hours. T., Th., 11. Professor WILLIAMS.

Courses 3 and 4 must be preceded by course 3 in embryology.

4. Veterinary Obstetrics. Spring. Four hours. T., W., Th., F., 11. Professor WILLIAMS.

5. Veterinary Jurisprudence. Spring. One hour. M., 11. Professor WILLIAMS.

[Courses 1–5 will be given to second and third year men in 1898–99. See under Course 11.]

6. Clinical Veterinary Surgery; second year men. Fall, winter and spring. Three hours. Professor WILLIAMS.

7. Clinical Veterinary Surgery; third year men. Fall, winter and spring. Six hours. Professor WILLIAMS.

8. Special Surgery (chest, abdomen and anterior limbs). Fall. Five hours. M., T., W., Th., F., 11. Professor WILLIAMS.

9. Special Surgery (posterior limbs, skin). Winter. M., W., F., 11. Three hours. Professor WILLIAMS.

10. Zoötechnics. Winter. Two hours. T., Th., 11. Professor WILLIAMS.

11. Special Surgery (genito-urinary organs, castration). Spring. Five hours. M., T., W., Th., F., 11. Professor WILLIAMS.

[Courses 8–11 will be given to second and third year men in 1899–1900. See under Course 5].

12. Research and Thesis. Three hours throughout the year. Professor WILLIAMS.

COMPARATIVE PATHOLOGY, BACTERIOLOGY AND MEAT INSPECTION.

The instruction in pathology and bacteriology is given by means of lectures, recitations and laboratory work. In general pathology the students are drilled in the definitions and in the nature of the morbid changes included in this subject. In general pathology Ziegler's text book is followed but supplemented by the results of more recent investigations as they are found in current literature and special monographs.

Pathological histology will receive special attention. In this work the students will be taught, by actual laboratory work, the methods of preparing permanent preparations and of examining diseased tissues in the fresh condition. They will have the privilege of studying blood and of counting the red and white corpuscles. For this highly important work the laboratory is especially well equipped. For the general arrangement of the laboratory see Plates III and IV.

The fall term in bacteriology is devoted to methods. The laboratories are well supplied with the best modern apparatus. The students will, under proper supervision, prepare culture media, make various cultures and study the morphology of bacteria in both the fresh (living) condition and in stained cover-glass preparations. In fact, all of the technique necessary for a practical working knowledge in bacteriology will be carefully covered. In the winter the more important species of pathogenic and economic bacteria will be studied. The special methods for the bacteriological analysis of milk and water, and those which are necessary for investigating diseases, such as tuberculosis, anthrax, glanders and the infectious swine and poultry disorders will receive careful attention. In the spring term each student will have an opportunity of carrying out independently some investigation, thus applying bacteriological methods in a practical manner. The lectures in the spring term will deal with applied bacteriology. In this course will be considered disinfection, sterilization, the means by which pathogenic bacteria are disseminated, protective inoculation, serum therapy in animal diseases, and other kindred subjects.

For those who wish to do advanced work in either of these subjects excellent facilities are afforded by way of a separate room and apparatus. As we are constantly investigating outbreaks of infectious diseases, among animals in the state, an abundance of working material is assured. This enables the student to come into touch with actual work in bacteriological diagnosis.

As is seen from the above, it is the aim of this department to drill the students by means of actual work in the technique necessary for them to successfully apply in their future professional duties the knowledge acquired in the study of pathology and bacteriology. To this end the courses of instruction have been carefully arranged, and for this purpose the laboratories have been equipped.

COURSES.

1. General pathology. Fall term. This course is open to students who have had Normal Histology and at least one year's work in Anatomy and Physiology. Lectures and recitations. Two hours. T., Th., 9. Professor MOORE.

2. Pathology of infectious diseases. Winter term. This course is open to students who have taken Course 1 and have taken or are taking

Course 4. Lectures and laboratory work. Two hours. T., 9. Professor MOORE and Instructor REED.

3. Meat Inspection. Spring term. This course is open to students who have taken Courses 1 and 2. Lectures and laboratory work. Two hours. T., 9. Professor MOORE and Instructor REED.

4. Bacteriology. Lectures and laboratory work. Three hours per week throughout the year. M., 9. Professor MOORE and Instructor REED.

5. Research in Pathology and Bacteriology. Laboratory work with lectures throughout the year. Professor MOORE and Instructor REED. The course is designed for those preparing theses for the baccalaureate or advanced degrees and for those wishing to undertake original investigation in Pathology and Bacteriology. This course is open to students who have taken Courses 1 and 2 if the work is in Pathology or course 4 if in Bacteriology, or their equivalent in some other university. Elementary chemistry and a reading knowledge of French and German are indispensable for successful work in this course.

GRADUATE AND RESEARCH WORK.

The opportunities for study and investigation offered to advanced and graduate students in the college and in the various departments of Cornell University are very great. The situation of the college gives it a great variety as well as an abundance of material for research, and the facilities for prosecuting the work are ample. Each student, as a part of his last year's work, must write a thesis giving the results of a personal investigation upon some subject in veterinary medicine. See under requirements for graduation, p. 20). To students preparing theses and to graduate students every opportunity and encouragement will be offered for carrying on independent investigations. (For the special courses offering thesis and research work see under the various departments pp 22–37).

THE VETERINARY LIBRARY AND OTHER LIBRARY FACILITIES.

THE FLOWER VETERINARY LIBRARY.—By a gift of five thousand dollars ($5,000) to Cornell University for the purpose, the *Honorable Roswell P. Flower* laid a broad foundation for a thoroughly good working, veterinary library. The books and periodicals obtained with this fund have been considerably increased by donations from various persons and by books obtained from the income of the college; the Veterinary Library is also largely supplemented by the University Library, and by loans of books and periodicals therefrom.

The Periodical Room (Pl. II) at the college is open daily from 7 A. M. till 6 P. M., and contains the leading veterinary and medical periodicals in English, French and German. In it are also found Foster's Encyclopædic Medical Dictionary and the Index Catalog of the Medical Library of the Surgeon General's Office.

The Veterinary Library Room (Pl. II) is open for free consultation, and contains most of the books and bound periodicals belonging to the library or loaned to it from the University Library. Books bearing especially upon the work of any laboratory course, are kept upon the book shelves of the laboratory where they are constantly accessible.

The books and bound periodicals and transactions in the University Library (Pl. IX) upon veterinary and human medicine, with allied sciences, exceed ten thousand (10,000) volumes ; and over 600 periodicals and transactions are received. Many of them pertain directly to medicine and biology. To all the University library facilities the veterinary students have free access in the library reading room, which is open daily from 8 A. M. to 11 P. M.

SEMINARY.

The Veterinary College Seminary, which meets every two weeks, has for its membership : (1) All members of the instructing body ; (2) All students preparing theses in the college ; (3) All students doing graduate and research work.

The purpose of the Seminary is : (a) To discuss the methods for advanced and independent work, that is such work as is expected of those preparing theses or prosecuting any special investigation ; (b) The presentation of the results of investigations and the progress of knowledge in the various departments ; (c) Reports by students of the progress of their work.

Naturally the members of the faculty take a leading part in (a and b) but as soon as the advanced work of students is well begun, the students present before the Seminary the results of their work.

At each meeting, after the report, the subject is open to all the members of the Seminary for questions and discussion. From the experience of the last two years it is believed that the Seminary is one of the most important parts of the college curriculum for preparing students for the duties and responsibilities of an honorable professional career.

SOCIETY OF COMPARATIVE MEDICINE.

This is a student society organized for the purpose of giving mutual aid in gaining general and special medical knowledge, facility in conducting the exercises of the meetings and in presenting papers and discussions in a clear and forcible manner before an audience.

TUITION AND LABORATORY FEES.

In the words of the law for the administration of the New York State Veterinary College : "No tuition fee shall be required of a student pursuing the regular veterinary course, who, for a year or more immediately preceding his admission to said veterinary college shall have been a resident of this state."

For students, not residents of New York State, the tuition is $100 per annum, $40 to be paid at the beginning of the fall, $35 at the beginning of the winter and $25 at the beginning of the spring term.

Laboratory fees.—Every person taking laboratory work is required to pay for the material actually used. This will average approximately $25 per year.

At the end of the course a fee of $5.00 is required of each student receiving a degree.

Living expenses in Ithaca vary from $3.50 to $10 per week. Books, instruments, stationery, etc., cost $10 and upward per year.

THE HORACE K. WHITE PRIZES.

These prizes, established by Horace K. White, Esq., of Syracuse, are awarded annually to the most meritorious students in the graduating class of the college. One prize of $15 to the first in merit; to the second in merit, a prize of $10.

POSITIONS AS DEMONSTRATORS.

At present one or more demonstrators in Anatomy are appointed each year at a salary of $125.00. These positions are open to members of of the graduating class and to graduates of this college who have shown special proficiency in anatomy.

APPENDIX A.

OPENINGS FOR VETERINARIANS IN AMERICA.

1st. In the United States Cavalry and Artillery there is a demand for a limited number of veterinarians.

2nd. In the Bureau of Animal Industry, U. S. Department of Agriculture, a number of veterinarians are employed professionally, as live-stock agents and inspectors; inspectors and superintendents of quarantine stations; investigators in bacteriology and pathology, and as meat inspectors. (By an act of Congress the federal meat inspectors must be graduates of a veterinary college).

3rd. In the different States there are appointments as State Veterinarians, and in some as County or District Veterinarians, to attend to preventable diseases of animals.

4th. The time is not far distant when each municipality must have its veterinary inspectors of markets, abattoirs and butcher meat, as well as of milk and other dairy products.

5th. Accomplished veterinary pathologists are needed in all the States to serve on tuberculosis and other commissions, so that work in this field may be conducted intelligently and successfully on scientific lines. Such work on our herds can only be carried on by those specially trained in the anatomy, physiology, hygiene and pathology of the lower animals.

6th. Educators in comparative pathology are wanted in Agricultural and Veterinary Colleges, and experiment stations, and must ere long be in demand for every Medical College which aims to keep abreast of the times.

7th. There are always openings in the wide field of private veterinary practice. With a ratio of three farm animals to every human being, and with less than one veterinarian to every ten doctors of medicine for man, the balance of opportunity seems to be largely in favor of the veterinary practice, and this preponderance must steadily increase with the recovery of stock values and with the increase in numbers and individual value of farm animals.

APPENDIX B.

Legal requirements for license to practice veterinary medicine and surgery in the State of New York. Extracts from article X, Ch. 860, laws of New York, 1895.

§ 171. "*Qualifications for practice.*—No person shall practice veterinary medicine after July one, eighteen hundred and ninety-five, unless previously registered and legally authorized, unless licensed by the Regents and registered as required by this article; nor shall any person practice veterinary medicine who has ever been convicted of felony by any court, or whose authority to practice is suspended or revoked by the Regents on recommendation of a State Board.

§ 176. *Admission to examination.*—The Regents shall admit to examination any candidate who pays a fee of ten dollars and submits satisfactory evidence, verified by oath if required, that he (first) is more than twenty-one years of age; (second) is of good, moral character; (third) has the general education required in all cases after July first, eighteen hundred and ninety-seven, preliminary to receiving a degree in veterinary medicine; (fourth) has studied veterinary medicine not less than three full years, including three satisfactory courses, in three different academic years, in a veterinary medical school registered as maintaining at the time a satisfactory standard; (fifth) has received a degree as veterinarian from some registered veterinary medical school. The degree in veterinary medicine shall not be conferred in this state before the candidate has filed with the institution conferring it, the certificate of the Regents that three years before the date of the degree, or before or during his first year of veterinary medical study in this State, he has either graduated from a registered college or satisfactorily completed an academic course in a registered academy or high school; or has a preliminary education considered and accepted by the Regents as fully equivalent." [See pp. 8–19 for preliminary educational requirements].

§ 178. *Examinations and Reports.*—Examination for license shall be given in at least four convenient places in this State and at least four times annually, in accordance with the Regents' rules, and shall be exclusively in writing and in English. Each examination shall be conducted by a Regent examiner, who shall not be one of the veterinary medical examiners. At the close of each examination, the Regents' examiner in charge shall deliver the questions and answer papers to the board, or to its duly authorized committee, and such board without unnecessary delay, shall examine and mark the answers and transmit to the Regents an official report, signed by its president and secretary, stating the standing of each candidate in each branch, his general average, and whether the board recommends that a license be granted. Such report shall include the questions and answers and shall be filed in the public records of the university. If a candidate fails on his first examination, he may, after not

less than six months' further study, have a second examination without fee. If the failure is from illness or other cause satisfactory to the Regents, they may waive the required six months' study.

§ 179. *Licenses.*—On receiving from the State board an official report that an applicant has successfully passed the examination and is recommended for license, the Regents shall issue to him, if in their judgment he is duly qualified therefor, a license to practice veterinary medicine. Every license shall be issued by the university under seal and shall be signed by each acting veterinary medical examiner of the board and by the officer of the university who approved the credential which admitted the candidate to examination, and shall state that the licensee has given satisfactory evidence of fitness, as to age, character, preliminary and veterinary medical education and all other matters required by law, and that after full examination he has been found properly qualified to practice. . . . . Before any license is issued it shall be numbered and recorded in a book kept in the Regents' office and its number shall be noted in the license. This record shall be open to public inspection, and in all legal proceedings, shall have the same weight as evidence that is given to a record of conveyance of land.

§ 180. *Registry.*—Every license to practice veterinary medicine shall, before the licensee begins practice thereunder, be registered in a book to be known as the "veterinary medical register," which shall be provided by and kept in the clerk's office of the county where such practice is to be carried on, with name, residence, place and date of birth, and source, number and date of its license to practice. Before registering, each licensee shall file, to be kept in a bound volume in the county clerk's office an affidavit of the above facts, and also that he is the person named in such license, and had, before receiving the same, complied with all requisites as to attendance, terms and amount of study and examination required by law and the rules of the university as preliminary to the conferment thereof, and no money was paid for such license except the regular fees, paid by all applicants therefor; that no fraud, misrepresentation or mistake in any material regard was employed by anyone or incurred in order that such license should be conferred. Every license, or if lost, a copy thereof, legally certified so as to be admissable as evidence, or a duly attested transcript of the record of its conferment, shall before registering, be exhibited to the county clerk, who only in case it was issued or indorsed as a license under seal by the Regents, shall indorse or stamp on it the date and his name preceded by the words: "Registered as authority to practice veterinary medicine, in the clerk's office of ——— county." The clerk shall thereupon give to every veterinarian so registered a transcript of the entries in the register, with a certificate under seal that he has filed the prescribed affidavit. The licensee shall pay to the county clerk as a total a fee of one dollar for registration, affidavit and certificate."

CATALOG OF STUDENTS.

1897–1898.

THIRD YEAR STUDENTS.

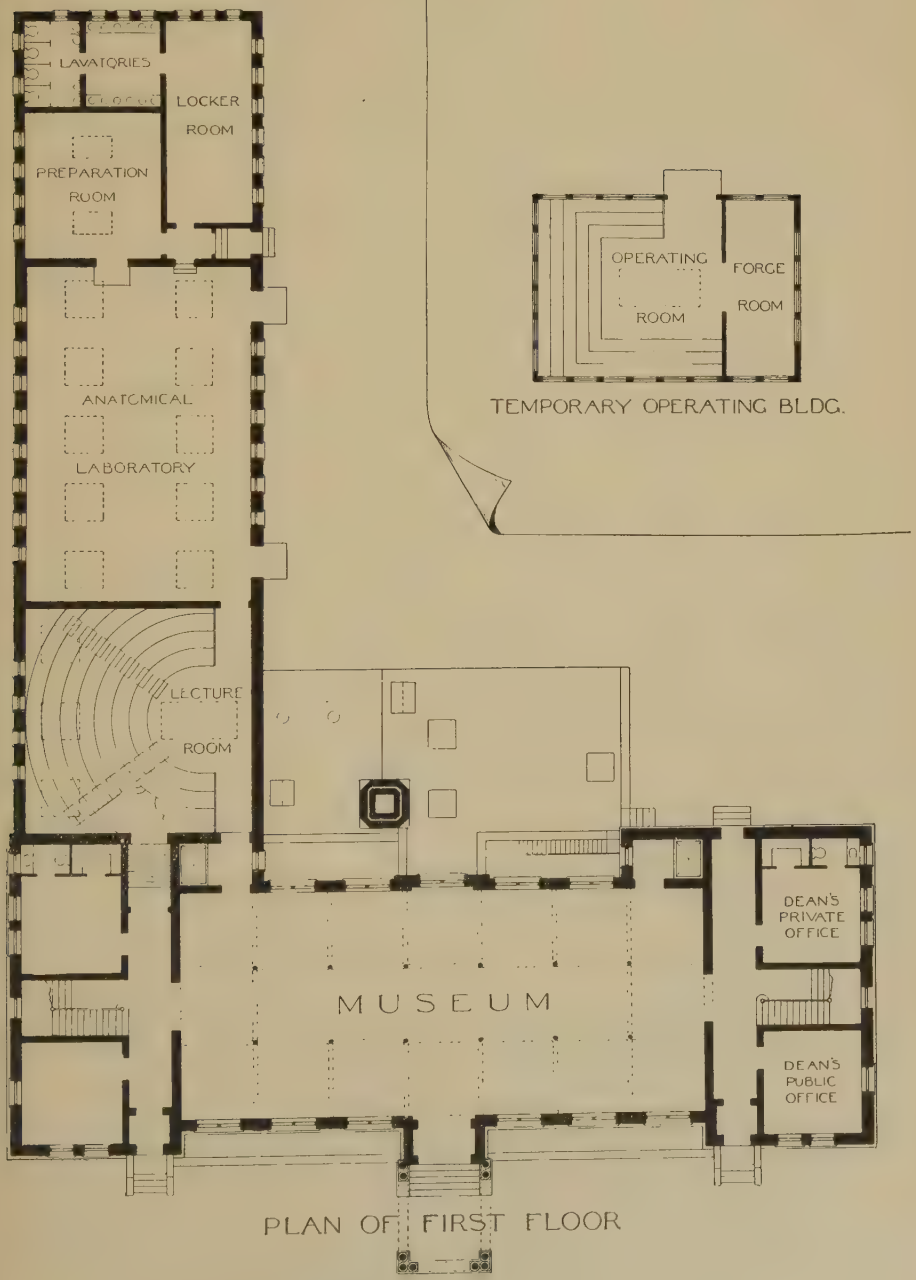
Dustan, A. W. ..... Morristown, N. J.
Kelly, A. B. ..... Albany
Lehrman, H. J. ..... Montclair, N. J.
Moore, E. L. ..... Halifax, N. S., Canada
Stanclift, R. J. ..... Derby

SECOND YEAR STUDENTS.

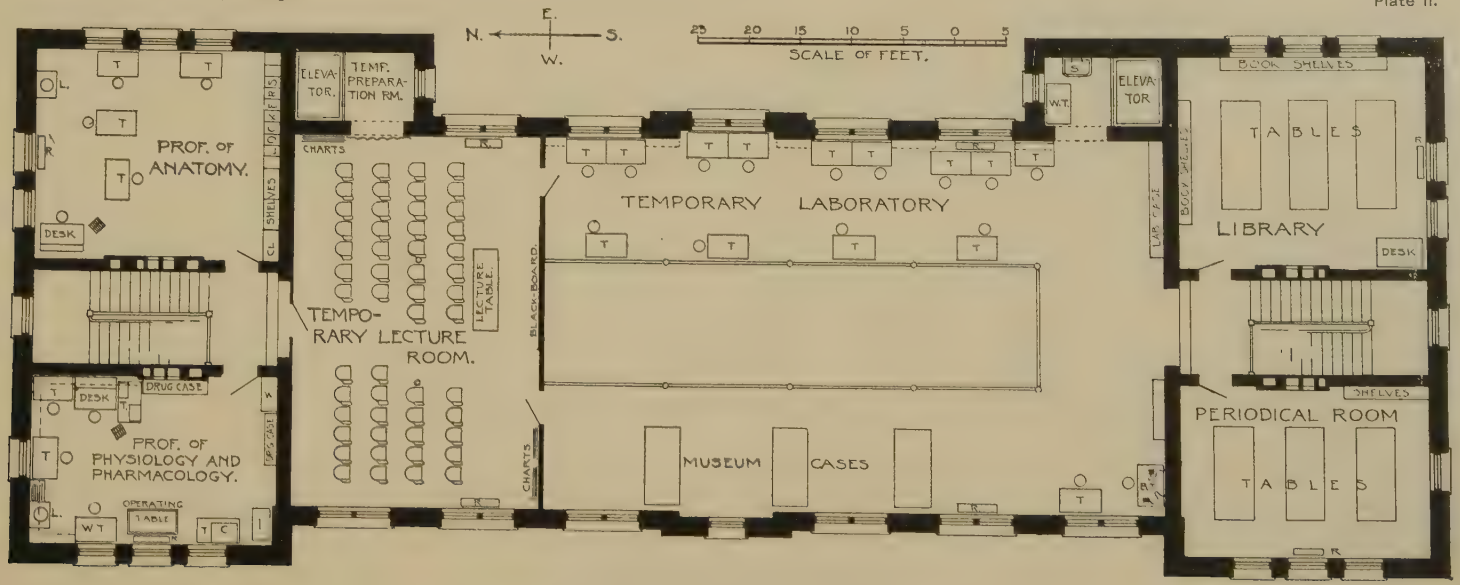
Fish, P. A. ..... Ithaca
Gay, C. W. ..... Ithaca
Hopkins, G. S. ..... Ithaca
Illston, H. W. ..... Ithaca
Kern, A. G. ..... Knoxville, Tenn.
Mitchell, W. J. ..... Ithaca
Perkins, C. R. ..... Hardy's
Potter, Chas. B. ..... Ithaca

FIRST YEAR STUDENTS.

Barnes, C. L. ..... Lockport
Juliand, Louis ..... Greene
Reed, R. C. ..... Ithaca
Stone, G. T. ..... Binghamton

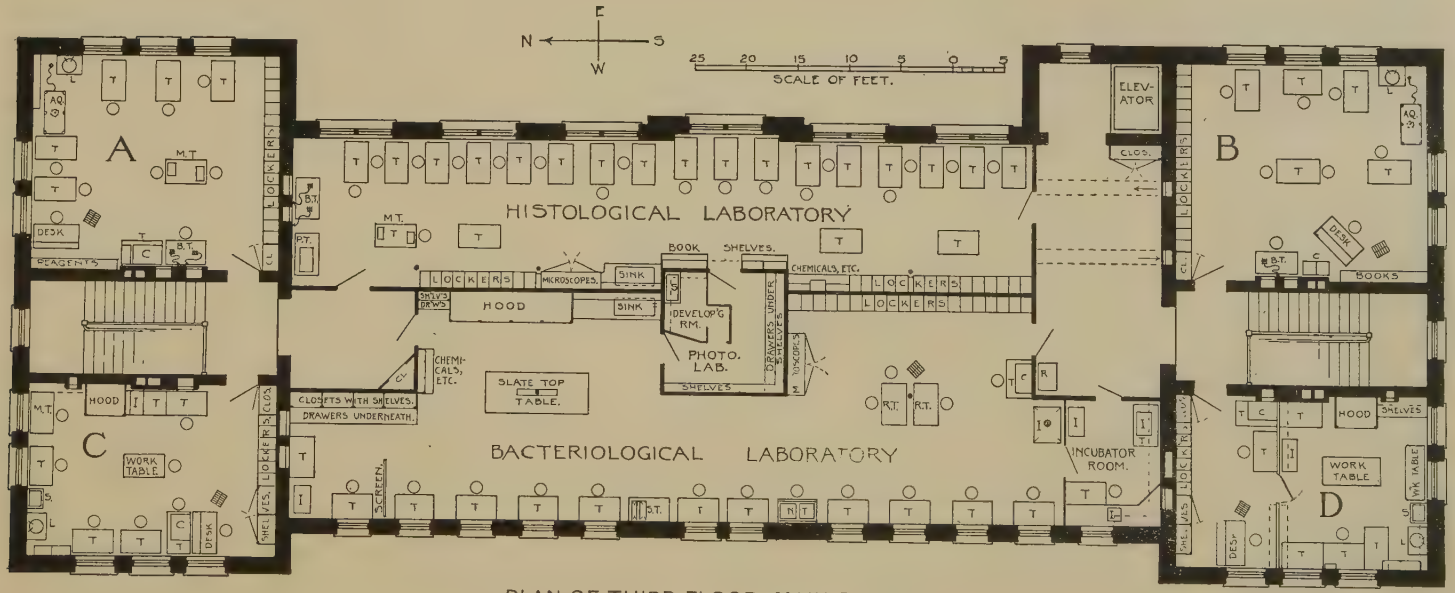


MAIN BUILDING.



Plan of Second Floor--Main Building.

TEMPORARY LABORATORY OF PHYSIOLOGY AND PHARMACOLOGY.



PLAN OF THIRD FLOOR--MAIN BUILDING.

A.—Laboratory for Research in Histology and Embryology

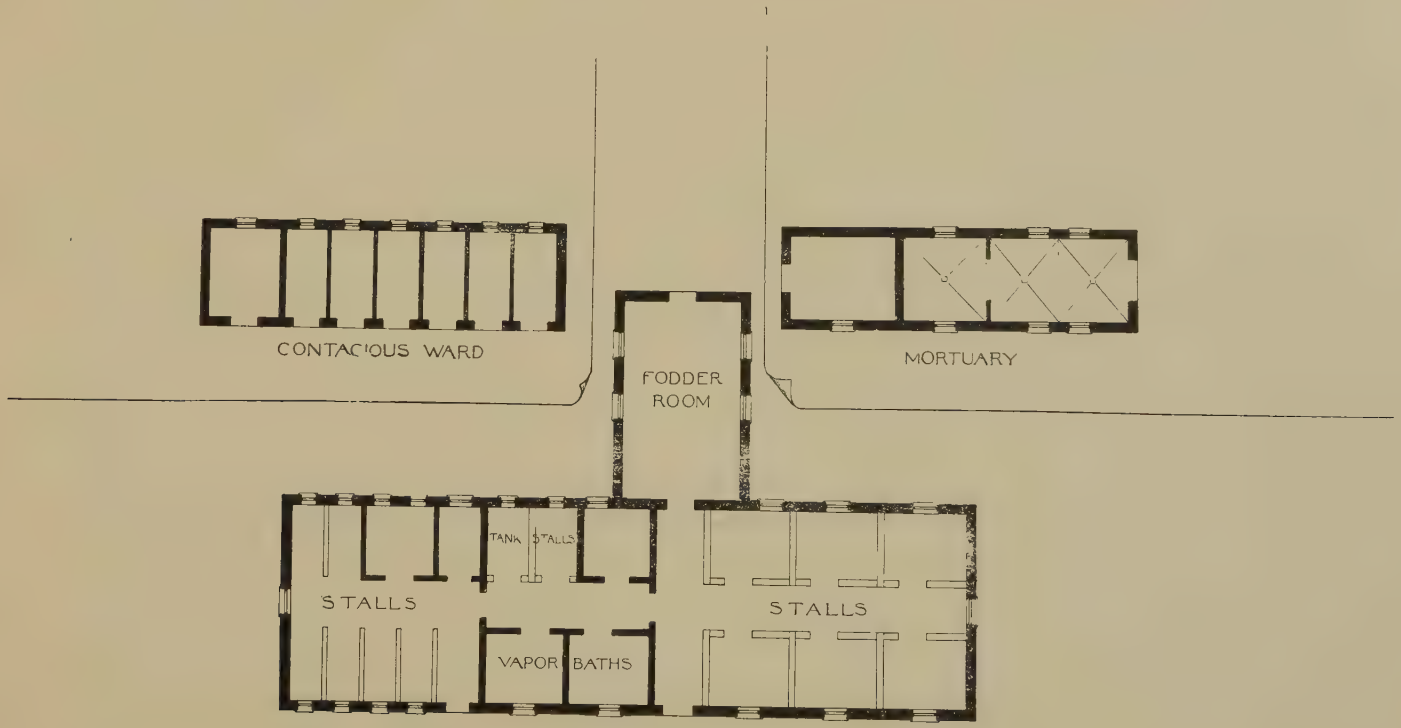
B.—Laboratory of the Professor in charge of Microscopy, Histology, Embryology

C.—Laboratory for Research in Bacteriology and Comparative Pathology.

D.—Laboratory of the Professor in charge of Bacteriology and Comparative Pathology.

GENERAL LABORATORY FOR BACTERIOLOGY AND PATHOLOGY.

GENERAL LABORATORY FOR MICROSCOPY, HISTOLOGY, AND EMBRYOLOGY.

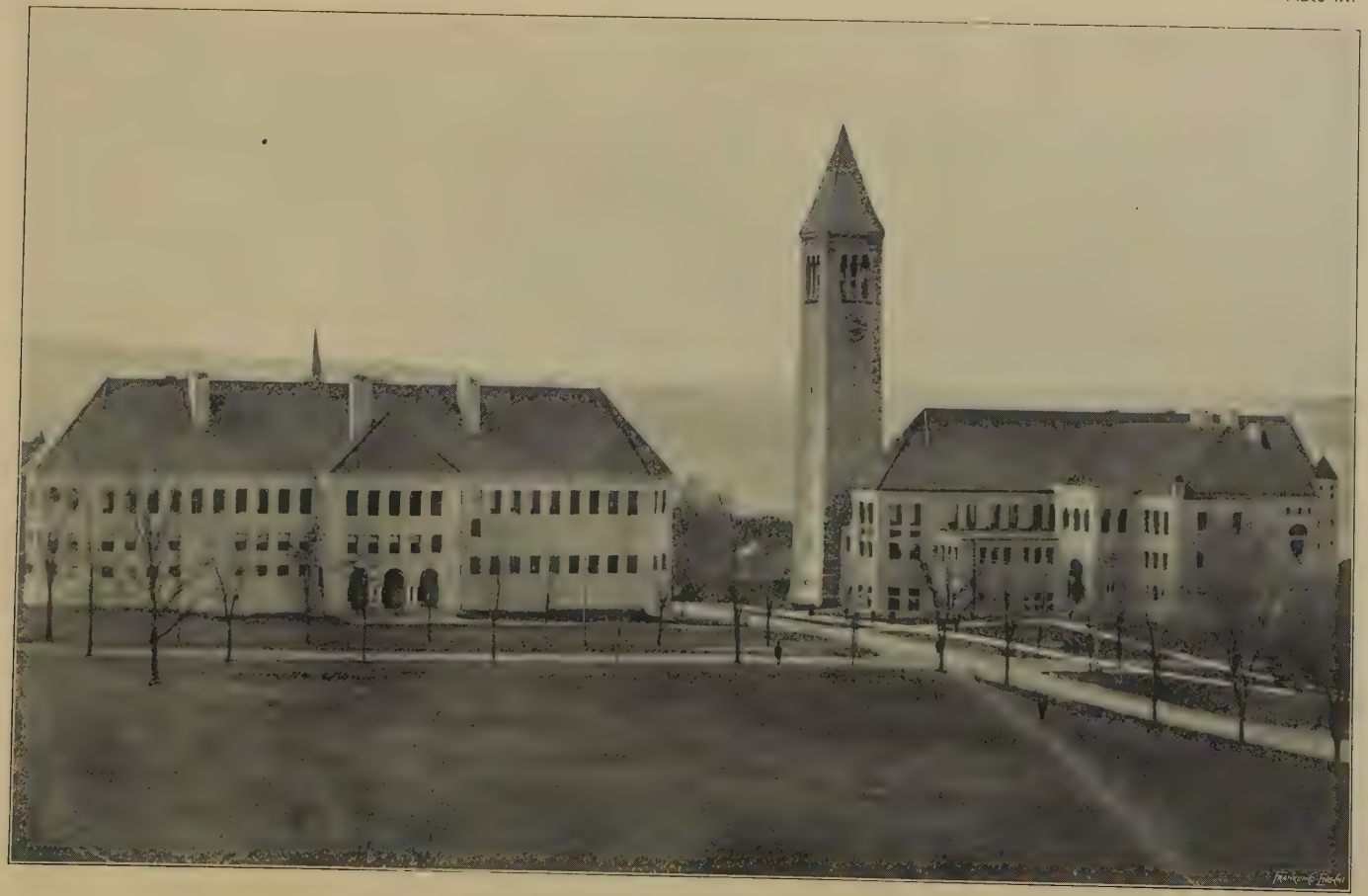


PLAN OF GENERAL WARD

CONTAGIOUS WARD AND MORTUARY.

MORSE HALL--CHEMISTRY.

DAIRY BUILDING--BREEDS AND BREEDING.



LAW SCHOOL AND UNIVERSITY LIBRARY—Looking South.

UNIVERSITY CAMPUS AND CASCADILLA BRIDGE--Looking North.

UNIVERSITY CAMPUS--Looking South from the Library Tower.